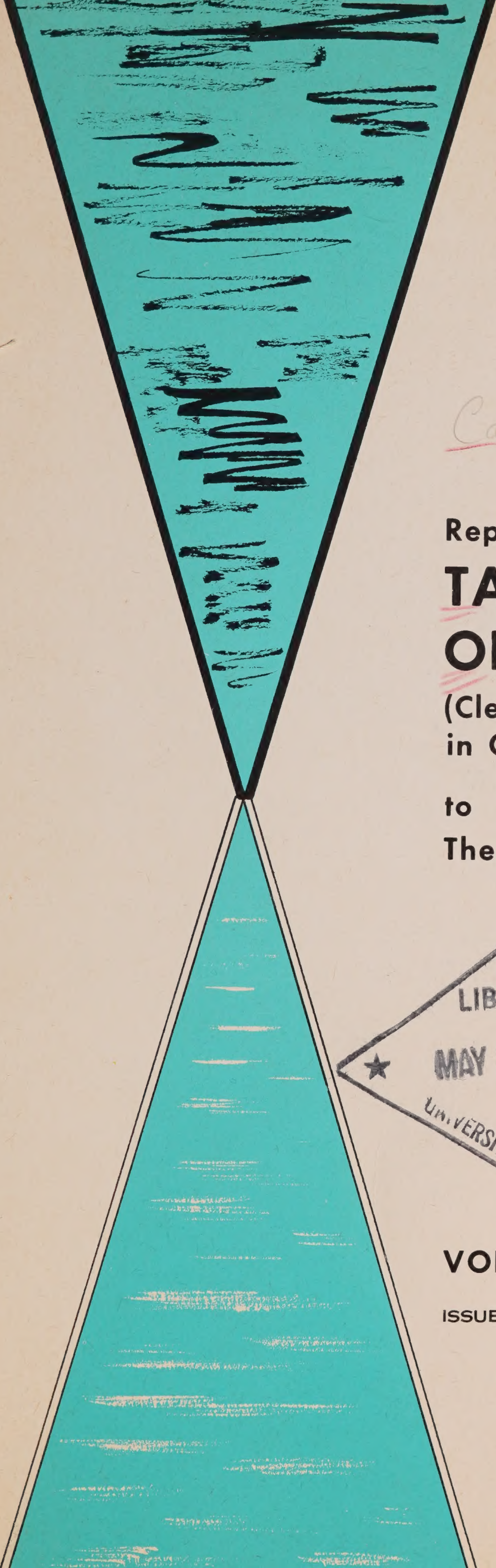

Canada

Report of the

TASK FORCE - OPERATION OIL

(Clean-up of the Arrow oil spill in Chedabucto Bay)

to

The Minister of Transport

VOLUME III

ISSUED BY THE MINISTRY OF TRANSPORT

Report of the

TASK FORCE - OPERATION OIL

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Ottawa, 1970
Cat. No.: T22-2470/3

VOLUME III

REPORTS OF OTHER UNITS TO THE TASK FORCE

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PART 1

REPORT OF TASK FORCE OPERATIONS OFFICER

CFB Shearwater
Shearwater, N.S.

13 May 1970

REPORT ON OPERATION OIL

The purpose of this report is to provide a picture of the Maritime Command involvement in Operation Oil and to recommend ways of improving such involvement in future disasters of this nature.

D.R. McNab
Lieutenant Commander

CHRONOLOGY OF EVENTS

4 Feb	– ARROW grounded on Cerberus Rock
11 Feb	– LCDR HOLLYWOOD arrived at Port Hawkesbury.
12 Feb	– After end of ARROW sank.
13 Feb	– VCDS authorized military to assist DOT.
14 to 21 Feb	– Various ideas put forward to salvage oil. Some attempts at beach cleanup made with Flame Throwers and glass beads.
21 Feb	– DR. McTAGGART-COWAN, CAPTAIN MARTIN and DR. SHEFFER arrived at Port Hawkesbury.
24 Feb	– Task Force requested military to setup operations co-ordinating centre.
27 Feb	– Curb sailed from New York – YMT-12 arrived at Chedabucto Bay.
2 Mar	– Curb Arrived
12 Mar	– Whale moored over the wreck for the first time.
13 Mar	– Commenced pumping oil.
17 Mar	– Storm caused Whale to part 3 of 4 mooring lines. Barge brought to Mulgrave.
22 Mar	– Curb and Whale returned to wreck site.
25 Mar	– Oil spill occurred. Centre Bunker Tank Contingency plan actioned at 1810 local.
26 Mar	– Contingency plan ceased at 1335 local.
1 Apr	– Narwhal departed – Cape Scott arrived.
11 Apr	– Ceased pumping operation at ARROW. All tanks in stern appear empty – time 1335 local. Total oil recovered 36,924 bbls.
15 Apr	– Curb departed Mulgrave at 1535 local bound for Halifax with Whale in tow.
16 Apr	– Contingency troops and aircraft released.
17 Apr	– Air Control van released.
19 Apr	– 2 Field Squadron & vehicles minus a retard party of six men returned to Gagetown.

	— Army Field Radio net returned to Gagetown.
22 Apr	— Cape Scott departed.
28 Apr	— Vessel sentry established over wreck as a result of attempted salvage of screw by divers.
6 May	— Army field telephone from 2 Sigs Sqdn returned to Gagetown
8 May	— Retard party from 2 Field Sqdn returned to Gagetown.
10 May	— Operations Officer returned to proper unit. Remnants under Maj C. Vance will disperse within one week.

COMMAND AND CONTROL ASPECTS

1. A centralized command and control function was built progressively from 21 February on. From early March, as the project developed and more experience was gained, the operations center was normally capable of seizing problems and tasks and either arranging solutions or passing the problem to units who were able to effect solutions. Several organization charts exist, however the essential policy direction for each unit came from the Task force, usually direct, then Operations in conjunction with the many units involved worked out any necessary details.

2. Each evening originally at 2000, and towards the latter half at 1800, a heads of departments meeting was held, in a conference room in the basement of the Port Hawkesbury Motel. At this meeting each section reported their days work and intentions for the next day. As the meeting progressed various co-ordination requirements were assigned to operations. These items were sometimes sorted out immediately, and at other times were sorted out after the meeting.

3. The military will doubtless become involved in any situation when personnel are required for Command and Control. There will also be many other agencies involved. Here in particular were:

a. Department of Transport

b. Defence Research Establishment Atlantic

c. Bedford Institute of Oceanography

d. Pacific Salvage Company

e. Irving Oil Company

f. Imperial Oil Company

g. Six motels; and,

h. countless itinerent contributers.

These agencies were all in addition to approximately 120 military personnel. At any one time there was considerable difficulty in defining areas of responsibility. It was finally clear that the operations section must assume responsibility for everything and then delegate as much as possible in order to keep the workload within reason. This created some friction, however as operations became more capable the various units more willingly co-operated.

4. The operations organization which eventually worked best was the married Ops-Logs arrangement worked out by MAJOR HUGH TILLEY. By mid March everything was beginning to focus around operations. No routine or type of person seemed especially suited to the job. There was an Administrative Officer, a Construction Engineer, an Architect, an Argus Navigator, a stoker, an administrative clerk, a radar plotter and one communicator. These people were not all present at once however from the mix it can be understood that almost any trade was valuable in the operations center as long as the person concerned could stand eight hours of constantly ringing telephones. These people rotated every two weeks having worked steadily for 14 days. The turnover caused some problems in that new people were at least three or four days in getting to understand the organization. The morale was generally good, and while it would have been more enjoyable from an Operations Officer's point of view to have kept the people permanently the resulting morale problem would probably have destroyed the benefit obtained from continuity.

COMMUNICATIONS

5. The overall communications capability was adequate if somewhat complicated. The army VHF FM equipment was perhaps the most effective, for it could be deployed around the area to wherever it was required. When the range became too great, a rebroadcast capability was set up on Eddy Point thus allowing an unbroken communications capability. The single side-band transceiver proved effective on several occasions when the Amplitude Modulated H/F would not work, however all units were not equipped with this capability therefore its usefulness was limited. The fisheries vessels had crystal controlled AM H/F equipment. These sets worked well within the fisheries communications net however great trouble was experienced in attempting to find proper crystals for the Task Force common frequency 2716 KCS. The Coast Guard vessels experienced this same difficulty, however the Coast Guard was able to communicate with the aircraft on 122.7 Mhz and they were the only vessels able to do so. The choice of a common frequency (2716 KHZ) was achieved by finding one which most ships had in common which was not already over-crowded and then having those not equipped acquire the proper crystals. The frequency chosen was in fact a US Coast Guard frequency which while not ideal was at least relatively clear of other traffic. Due to the nature of the communications problem, operations was required to direct the solution. One very ideal solution would be to have a Canadian contingency common frequency allocated to H/F, VHF, and UHF equipment so that whenever these various agencies become involved, a common radio frequency can be quickly set up.

TRANSPORTATION

6. The Transportation Section consisted of a variety of vehicles, approximately 15 drivers and seven vehicle technicians. Perhaps the most valuable asset of all was the recovery vehicle which besides its normal work was able to provide a good mobile crane capability. This particular operations required an assortment of 2 ½ ton vans and trucks, some ¾ ton vans and trucks, jeeps, staff cars and station wagons. On two occasions the station wagon was used as an ambulance complete with stretchers and medical assistant. There is no doubt that a reliable and adequate transportation section is a necessity and it will probably have to be drawn from military sources.

7. Water transportation was a constant problem. The small 27 foot Special Purpose Barges could not easily take the sea at the wreck site and therefore the larger 50 foot LCM's were used. The LCM's were used in boom construction and mending and were sometimes not readily available for ferry work to the wreck site and back. The requirement for transport to be available immediately was never completely resolved, however the introduction of a fisherman to do a personnel run morning and evening as well as other special and emergency runs was a great help. The barge fleet was not under the control of operations as Mr. STUART of DOT was available to control these vessels. The smaller ones not having radios, he was required to motor to or phone these crews each night and give them their next day's instructions. Some emergency instructions were passed by helo and some via other vessels. In all, this system worked though sometimes with no proper assurance that the instructions had been received.

8. The two DOT Bell Jet Ranger Helicopters each capable of carrying 3 passengers were the backbone of the air component. These aircraft rotated periodically as did the pilots and never once was a flight aborted due to mechanical troubles. They were controlled directly by operations and operated almost continuously during the daylight hours. The Voyageur helicopters from St. Hubert provided excellent heavy transport for working parties and equipment to remote areas during their deployment. These machines also served well during the contingency by bringing 50 troops to aid in deploying peat along the shore. Control of these aircraft was exercised by telephone and radio from operations. The proper safety and control requirements were greatly facilitated by having the mobile control tower, able to transmit and receive on UHF, VHF and H/F AM & SSB.

ACCOMMODATION

9. Accommodation for personnel consisted of motels, CCGS Norwhal, Canadian General Electric construction camp and HMCS CAPE SCOTT when NORWHAL had departed. The general plan was to have those people who were most essential to the operation in the motel where operations was. There were two motels in Arichat where the divers, stokers and because of the availability of a landing area, the Voyageur crews were housed.

10. Accommodation was extremely critical and it was necessary for operations to closely monitor the requirement versus the availability. When the demand exceeded the available space the Canadian General Electric construction camp was used. The construction camp accommodation is a trailer concept, and was used basically as watchkeeper accommodation. This proved quite satisfactory and was superior to the ship accommodation, for watchkeepers.

LOGISTICS

11. The Logistics Officers rotated every two weeks and therefore no comprehensive report will be made by them. The main purpose of having the Logistics Officer in operations was to originate all the requests for services and equipment as soon as the requirement became known. Generally the Logistics Officer would call upon Military and Department of Transport sources first. If these could not provide or if they seemed unlikely, then commercial sources would be approached. As soon as something positive was received and an acceptable delivery time given, then all other sources would be turned off. It was possible to do this because Mr. JIM SQUIRES the DOT Logistics Accountant was able from his experience to determine whether the quoted cost was within reason. Had we not had the benefit of Mr.Squire's knowledge in this respect then much time would have necessarily been wasted waiting for all sources to reply in order to get the right price.

12. The whole logistics problem was affected greatly by the urgency of the situation and in this respect the boilers caused the most trouble. The boiler feedwater and storage tanks were not up to standard. The temperature on at least two occasions became so low that the feed water supply line froze up thus stopping the boiler. Future operations of this nature must include a more reliable boiler. The one used was a Vapour Clarkson Steam Generator which was too sensitive to the less than ideal conditions. Mr. R.E. SMITH of the Dockyard Mechanical Department in Halifax recommends two horizontal water-tube boilers of the Scotch Dry-back type. This will allow one boiler to shut down for repairs while the other carries the full load.

The boiler should have a minimum of 150 lbs pressure, and while it would be slower to start this type of boiler, once heated it would not shut down instantly when feed water problems are encountered as it has 1100 gallons of water inside.

13. The Irving Whale was the pumping platform and the oil recovery vessel. The logistics and command problems encountered were unique in that five groups of people were involved each responsible for separate functions. They were:

a. The Curb crew consisting of five or six men per watch who tended the pumps and steam lines and were responsible for hauling up or unhooking the hoses,

b. the civilian boiler tenders, two in number who tended the forward or small boiler,

c. the Armed Forces stokers, about seven in number plus one Armed Forces Electrical Technician who tended the Vapour Clarkson steam generator and the 30 KVA diesel generator and provided electrical expertise on the barge generally;

d. the crew of the YMT-12 who were responsible for the diving operations; and,

e. the Irving OIl crew of two men who were the barge tenders.

Parts such as fan belts would break and no-one knew what size they were. A small package of fuses similar to those used in automobiles was delivered to the barge by helicopter. There were no spare light bulbs on the barge and these were supplied only when someone realized that nearly all the light bulbs were burned out. Rags, spare lengths of wire, tools, boiler and diesel fuel and many other items were delivered by landing barge after they had run out. All of the people onboard Whale did a magnificent job when everything is considered, however their ability to perform as a unit was hampered due to lack of anticipating and co-ordination. That the operation was successful at all was largely due to the ceaseless efforts of CAPTAIN SVEN MADSEN and CAPTAIN BOB BELSHER who spent a great deal of time on the barge overseeing the operation.

THE OIL SPILL CONTINGENCY

14. The oil spill occurred late on the afternoon of Mar. 25th. While not a great deal of direct results occurred from the well laid plans, it was possible to keep track of the oil and the peat was stock piled and troops were deployed if it had come ashore.

The lessons learned were that little can be done to contain the oil at night. If it were possible to get the equipment into position prior to darkness, then it would be possible to carry on through the night with containment.

CONCLUSIONS

15. There was not adequate co-ordination at the wreck site for at least 20 days after the ARROW went aground. This allowed many individuals and units to attempt measures which were either not effective or which were not able to be followed through.

16. The appointment of the Task Force and the subsequent creation of the operations center seemed to bring about some order.

17. The evening meetings whereby up-to-date information was divulged and Task Force policy direction was given proved very effective.

18. The operations co-ordination centre which contained the Operations Officer (sea and air qualified) and the Logistics Officer (basically in this case Construction Engineers with Army background) provided a workable base for operations. This staff may require augmenting or variation to suit the emergency. Watchkeepers will be required depending on the workload.

19. Each element was capable of communicating internally, however, it would be a good idea to allocate a contingency frequency on UHF, VHF and H/F and make provision for all units to operate such a net when required.

20. Vehicle transportation was very essential to the success of this operation. The mix must be determined from the requirement.

21. Water transportation in this oil spill contingency was good although control was not too positive. The area of the emergency and the vessels available will always vary but positive control of these vessels is essential if efficient and timely use is to be made of them.

22. The DOT helicopters provided a most necessary service in their work of flying oil observers and transporting personnel and supplies. The Voyageur helicopters were most useful for the heavy work required and aided considerably in getting the task done more quickly.

23. The mobile control van provided by CFB SHEARWATER was the primary air communications and control centre. This vehicle was a most necessary part of the operation.

24. Accommodation was adequate considering all problems generally. The construction

type trailers provided the most economical facilities and were apparently quite comfortable. If any remote accommodations are required these would probably be the best in a winter environment. Ships do not make good hotels for people working 24 hours per day and should be avoided if possible. This is not meant to detract from the excellent services provided by Narwhal and Cape Scott.

25. The Logistics was essentially controlled by DOT, however the requirements were set up by the operations co-ordination center. If the military were ever required to provide complete supply accounting a more comprehensive system would be required.

26. The pumping out of a sunken tanker will probably not occur too often, however, should it ever occur again, a more appropriate type of boiler should be chosen, and a more centrally controlled and administered barge crew should be established.

27. The oil spill contingency plan was hand crafted for the peculiarities of the situation in Chedabucto Bay. Future disasters of this nature would require a similar plan designed for the problem at hand.

RECOMMENDATIONS

28. It is recommended that:

a. when a disaster occurs, military personnel be sent in to recce the area and determine the requirements so as to be ready if and when called,

b. the Task Force concept be retained, as this allows all departments in the National sense to work for a single leader, thus avoiding inter-departmental disagreements,

c. the operations personnel be chosen to suit the situation, operations experience is not as essential as the trade background,

d. a common UHF, VHF and H/F contingency frequency be assigned so that a communications plan can be quickly established,

e. sea, land and air transportation requirements must be assessed early and proper equipment and facilities provided,

f. a control tower be provided for safety and control,

g. accommodation requirements be assessed and provided prior to deployment of personnel; and,

h. a supply and accounting capability be provided on site to work alongside the operations co-ordination centre.

VOLUME III

PART 2

METEOROLOGY

OPERATION OIL

METEOROLOGY

As soon as the Task Force arrived at Port Hawkesbury it was obvious that a closely knit on site meteorological service was essential and that supplementary meteorological observing stations throughout the Bay were required.

Lieutenant Commander M.R. Morgan, OIC MFWC, arranged for the provision of this service using personnel assigned to Maritime Forces.

The Regional Meteorologist (MOT), Moncton, installed additional observing equipment around the Bay to meet Lt-Cmdr Morgan's requirements and instructed the temporary observers.

The meteorological office was an Army vehicle drawn up outside the Port Hawkesbury Motel (Operation Oil Headquarters).

From 21 to 26 February service was provided by the Atlantic Weather Central from Halifax.

From 26 February to 31 May, 24-hour on site service was provided by MFWC.

From 1 June to 30 June special service by direct line was provided by MFWC from Halifax.

After 30 June requirements were met by the regularly available public and aviation services.

An ice forecasting service was provided by the Ice Forecasting Centre in Halifax.

These services made an essential contribution to the safety and efficiency of the entire operation.

A summary of the weather conditions in Chedabucto Bay from 4 February to 30 June is contained in Attachment A. Some detailed observational data for the period 4 February to 25 February are presented in Attachment B.

WEATHER SUMMARY FOR CHEDABUCTO BAY

February 4 to June 30, 1970

Wednesday, February 4

Strong southwesterly flow over Maritimes ahead of frontal system oriented parallel to and along United States east coast.

Thursday, February 5

Cold front moved east of Cape Breton about midnight with cold ridge building in to west of front. Ridge or high remained over area until 1200Z, 6 February.

Friday, February 6

With ridge holding along the east coast of North America, and frontal through about 5 degs. lat. offshore, a persistent northeasterly flow developed over eastern Nova Scotia until 06Z, 9 February.

Monday, February 9

High moving east from Quebec covered Maritimes until 18Z, 10 February.

Wednesday, February 11

Southeasterly gradient intensified with approach of storm along New England coast.

Thursday, February 12

Storm Centre moved into New Brunswick, with gale winds subsiding over east coast Nova Scotia by 06Z, 12 February. Strong southwesterly flow over Maritimes until 00Z, 13 February.

Friday, February 13

Moderate westerly circulation about a deep low in northern Quebec.

Saturday, February 14

Moderate northwesterly flow over northern Nova Scotia weakening on

Sunday, February 15

as high moves over Nova Scotia from the southwest.

Monday, February 16

Low forms in Bay of Fundy with strong southeast winds developing over eastern Nova Scotia. Low moves to Gulf of St. Lawrence by 1200Z, 16 February, with northwesterly flow developing over Maritimes ahead of strong high moving east from southern Ontario.

Tuesday, February 17

Northwesterly flow weakens as high moves over Maritimes.

Wednesday, February 18

Ridge developed along east coast with trough offshore resulting in northeasterly flow in eastern Nova Scotia.

Thursday, February 19

Southwesterly flow developing ahead of cold front advancing eastward along east coast of Canada and United States.

Friday, February 20

Northwesterly flow developed in cold air west of the front, now offshore. Flow persisted until

Sunday, February 22

18Z when approach of low from central Quebec resulted in winds backing into the southwest. Southerly winds continued until cold front moved across coast of northern Nova Scotia 18Z, 23 February.

Tuesday, February 24

Strong northerly flow over Nova Scotia following the passage of the front, and persisted with gradual weakening and backing to the northwest until

Wednesday, February 25

Approach of wave from Great Lakes backed winds over Nova Scotia to south with winds shifting to the north early on.

Thursday, February 26

A low pressure centre moved northeastward through northern Quebec and Labrador at 40 knots. The cold front extending southward from the low passed through the area in the early morning followed by moderate to strong westerly winds behind the front. During the day the winds veered gradually to northerly. Light rain in the early morning changed to snow and then scattered flurries by evening. Waves in the Bay estimated 6 — 8 feet.

Friday, February 27

A deep through northeast to southwest through eastern Newfoundland and a ridge extending from Labrador to New Brunswick maintained northerly winds of 20-25 knots over the area. Skies were generally clear, however, there were a few snow flurries over the hills. Seas decreased to 4 — 6 feet.

Saturday, February 28

The ridge over New Brunswick weakened throughout the day while the trough moved slowly eastward. Surface winds were somewhat weaker at 15 — 20 knots. Winds backed from the north to northwesterly during the day. Skies were generally cloudy. Seas 4 — 6 feet.

Sunday, March 1

A low pressure centre moving northward through central Newfoundland developed a weak trough extending westward into the Gulf of St. Lawrence. The resulting northwesterly winds averaged 15 knots during the day decreasing to 10 knots in the evening. The sky was clear. Seas slight.

Monday, March 2

A high pressure centre over northern Quebec strengthened while the N-S trough through eastern Newfoundland moved slowly westward. Winds were light northwesterly in the morning but increased and veered during the afternoon to northerly 15 – 20 knots. Skies were partly cloudy. Sea slight.

Tuesday, March 3

The north south trough through central Newfoundland, with a well developed warm front embedded in it, gradually moved westward to lie through the extreme western portion of Newfoundland by evening. The overrunning warm air spread snow and freezing drizzle into the area rendering helicopter flying extremely hazardous. The northwesterly winds west of the front gradually increased to a maximum of 25 – 30 knots by evening. Seas increased to 3 – 4 feet.

Wednesday, March 4

The warm front became quasi-stationary just west of Newfoundland and east of Chedabucto Bay gradually weakening throughout the day. Skies were cloudy all day with snow and threatening freezing drizzle in the morning. A weakening northsouth ridge moved slowly eastward through Quebec maintaining strong northwesterly winds of 25 – 30 knots in the Bay. Seas 4 – 6 feet.

Thursday, March 5

The northsouth ridge continued moving eastward through New Brunswick weakening considerably. Winds were northwesterly 20 knots decreasing to less than 10 knots after dusk. Skies were mainly clear. Seas decreasing to 2 – 3 feet.

Friday, March 6

A weak low pressure centre about 600 miles south of Halifax deepened and moved northeastward slowly. This low produced light northerly winds over the Bay. Skies were generally cloudy with scattered snow flurries. Sea slight.

Saturday, March 7

The low pressure centre, now with a well developed arctic frontal system moved slowly eastward on a track about 600 miles south of Newfoundland. Winds gradually increased from light northwesterly to northwesterly 20 – 25 knots by evening as the low deepened. Skies were cloudy with occasional snow flurries. Freezing drizzle which had fallen overnight continued to be a threat. Seas increasing to 2 – 3 feet.

Sunday, March 8

Sunday morning a low pressure centre was located just south of Cape Race moving due north at 10 knots, causing a light northwesterly flow over Chedabucto Bay. Skies were overcast until late in the day when a weak ridge moved over the area. Winds slackened and backed to the west at 10 knots with partly cloudy conditions. A light chop covered the Bay during the day. A low temperature of 26 degrees was reached in the early morning and a high of 35 degrees late in the afternoon.

Monday, March 9

Overnight the weak ridge moved eastward followed by a low pressure centre from Maine which moved through the Bay of Fundy and then northward into the Gulf of St. Lawrence. The west winds freshened to 20 knots in the early evening as the low centre moved northward. While the Bay was under the influence of the ridge temperatures dropped to 22 degrees overnight and only rose to 30 degrees in the afternoon. Visibilities remained good under partly cloudy skies. Slight seas.

Tuesday, March 10

Monday night a complex low pressure system had developed over Anticosti Island. Winds remained westerly 15 — 20 knots at the outer reaches of the Bay and northwesterly 15 — 20 knots in the strait of Canso, but were generally light inside the bay. The sea state was below a foot. Skies were cloudy and a few snow flurries early in the day measured only a trace. Temperatures were more seasonable with a low of 25 degrees and a high of 30 degrees.

Wednesday, March 11

Chedabucto Bay continued to lie under the influence of the almost stationary low pressure area centred over Anticosti Island. The low had deepened overnight strengthening the winds over the bay. Green Island reported southwesterly winds of 28 knots in the early afternoon while Jerseyman Island reported southwesterly 15 knots. Skies were overcast with snow showers persisting throughout the day lowering the visibility at times to almost zero. Temperatures remained below freezing with a low of 18 degrees and a high of 28 degrees. Seas 2 — 3 feet.

Thursday, March 12

The complex low pressure system continued to dominate the winds over the bay until the evening when it moved northeastward off the coast of Labrador. The day was sunny but temperatures reached only 30 degrees with a low in the night of 18 degrees. Winds were west to southwest at 20 knots in the bay area dropping off to 10 knots in the early evening. The two to three foot seas present for the last two days dropped off to less than a foot as the winds diminished.

Friday, March 13

A weakening ridge moved across the Maritimes towards Newfoundland causing winds to be light westerly. Skies were overcast with thin cirrus as a result of a fairly intense storm centre south of Cape Hatteras. As the day progressed the low moved towards Sable Island passing Cape Cod in the late afternoon. Snow began about this time and winds backed to southwesterly 15 knots. A high temperature of 38 degrees was recorded with a low of 20 degrees the previous night. Seas began to build to 2 — 3 feet with a low ground swell running.

Saturday, March 14

By morning the storm centre was moving north passing Cape Breton Island 60 miles off shore. The snow, ending by morning, measured six inches while winds of 25 knots gusting to 35 knots from the northwest had been reported by Green Island and seas reached four to five feet. As the low centre passed Bonavista, Newfoundland, in the early evening, heading eastward into the Atlantic Ocean, winds dropped off to a light northwesterly breeze. Skies remained over-cast and seasonable temperatures were recorded. The low was 28 degrees and the high for the day was 32 degrees.

Sunday, March 15

In the wake of Saturday's storm a broad trough extended along the Maritimes. It was mainly cloudy with light southwesterly winds. Temperatures ranged from a low of 27 degrees to a high of 39 degrees. Seas 2 — 4 feet.

Monday, March 16

A weak trough off Cape Hatteras during the night began developing rapidly into a low pressure centre moving at 30 knots towards Sable Island in the morning. The day began with visibilities 2 — 3 miles in fog, light winds and sunny skies. By 1100 in the morning the winds had picked up to easterly 15 knots and it had become cloudy. Snow began to fall at 1300 with winds of 20 — 30 knots from the northeast. Visibility was reduced to

half a mile by the snow. The storm centre by this time had started to swing north and then northwest cutting through Nova Scotia between Halifax and Canso in the evening. Snow continued to fall until early evening. Gales of 35 knots gusting to 48 knots were recorded at Green Island while most lightkeepers in the bay reported winds of 30 – 50 knots. Seas of 8 – 9 feet were measured one mile east of Cerberus Rock. By midnight the storm had stalled over Prince Edward Island. Strong winds and high seas continued to be recorded. Despite the strong winds and falling snow, temperatures reached 33 degrees.

Tuesday, March 17

During the night the storm moved very slowly northward towards Port AuxBasques, Newfoundland. Winds of 30 knots gusting to 40 knots still from the southwest were reported in the morning. The highest waves were 6 feet and continued to subside steadily during the day until evening when 2 – 3 foot seas remained. Intermittent light snow continued to fall totalling three inches by late afternoon. Temperatures reached a maximum of 35 degrees and fell to 24 degrees during the previous night.

Wednesday, March 18

Skies were clear in the morning and a heavy frost occurred as a low of 20 degrees was reached. The storm centre had now moved well out into the Atlantic Ocean and Chedabucto Bay was under the influence of a high pressure area moving in front the great lakes. Winds were light to moderate over most of the bay with the strongest wind being reported by stations in Canso strait and in the outer lighthouses. Skies remained clear for the entire day and a maximum temperature of 41 degrees was reached. Slight sea and swell.

Thursday, March 19

Still under a high pressure area winds were light and sunny skies prevailed. A low temperature of 14 degrees was reached and a high of 42 degrees. There was no sea or swell.

Friday, March 20

With clear skies a low of 19 degrees was reached overnight. By morning some cirrus cloud had appeared in advance of a storm centre south of Cape Cod, but it was mainly sunny. A high of 42 degrees with light winds in the afternoon was reached. No sea or swell.

Saturday, March 21

The storm centre deepened as it moved northeastward towards Sable Island at 25 knots. Early morning fog gave way rapidly to a broken middle cloud condition with light easterly winds. The cloud amount increased during the day with rain beginning in the evening. Temperatures rose from a low in the mid 20's to a high in the mid 30's. Easterly swell 3 – 4 feet.

Sunday, March 22

Saturday's storm passed just south of Sable Island about midnight and continued to move northeastward at 25 knots during the day. The rain changed to snow with a brief period of freezing rain and ice pellets as the low passed Sable. During this time the wind backed to northerly 30 – 35 knots. Snow changed to a few flurries in the morning and these ended with skies clearing in the afternoon. Temperatures managed to reach the mid thirties after a low near 30 overnight. Sea and swell from E 6 – 8 feet.

Monday, March 23

Early Monday, the area was under the influence of a ridge extending south from a high over Labrador. This ridge moved quickly through the region however as a low moved along the New England coast into the Bay of Fundy. Monday morning saw only scattered cloud with a light northeasterly wind. However, with the approach of the low, skies became overcast around noon and a mixture of snow, ice pellets and freezing rain beginning in the evening and quickly changed to rain. The wind increased and veered throughout the day and by evening was southeast 30 knots. Temperatures during the day were fairly steady near the freezing mark. Seas 6 — 8 feet.

Tuesday, March 24

The low in the Bay of Fundy drifted north through New Brunswick and a trowal structure moved northeastward through Nova Scotia, passing through Chedabucto Bay about 0700 hours, at 15 knots northeastward. Winds dropped off quickly after midnight but remained southeasterly until the trowal passage at which time they veered to southwesterly 15 — 20 knots. With the trowal passage the rain ended but fog rolled in dissipating very slowly. A low overcast persisted throughout the day. Temperatures were again near the freezing mark during the day. Seas 4 — 6 feet.

Wednesday, March 25

The low in New Brunswick continued to be the dominating factor as it continued north northeastward into Labrador. Winds continued to be southwesterly to westerly around 15 knots. The fog thickened once again overnight but the visibility became very good by noon. Overcast skies in the morning and early afternoon gradually cleared by evening. High temperatures were in the mid thirties with the low at night around 30. Seas 2 — 3 feet.

Thursday, March 26

As the low moved into Davis Strait a ridge on a northwest to southeast line moved across Nova Scotia at 15 knots and passed through Chedabucto Bay at 1800 hours. Light westerly winds overnight veered to northwesterly 20 — 50 knots by mid morning and remained mainly clear throughout the day. Low temperatures were around freezing and highs in the upper thirties. Slight sea.

Friday, March 27

As the ridge moved to the east a complex system moved through the Great Lakes and New England States. By Friday evening the system had developed into one centre near Seven Islands, Quebec, with a trough extending southeastward though Chedabucto Bay. Winds increased to a maximum of southeast 40 knots in the afternoon. The winds veered to southwesterly 25 as the trough passed. Skies quickly became overcast with the approach of the trough and cold front. Rain began around noon and ended with the trough and frontal passage. Skies showed a rapid clearing at this time. The high temperature for the day was near 40 before the cold frontal passage after a low near 32. Short choppy sea 3 — 4 feet by evening.

Saturday, March 28

The low moved north into Quebec and a ridge moved through the region passing Chedabucto Bay about 1600 hours. Skies remained mostly clear and the wind veered from westerly 15 knots early in the morning to northwesterly 25 knots by daybreak then becoming light in the late afternoon. A high temperature in the upper thirties was recorded followed by a low around 30 overnight. Slight sea.

Sunday, March 29

As the high continued to move eastward, an intense low moved off the coast near Norfolk Sunday afternoon. A second low moved along the St. Lawrence Valley and by Sunday afternoon was located over southwestern Labrador with a trough extending to a low off Norfolk. Light winds in the early morning increased to southsouthwestward at 15 knots by daybreak and varied little for the remainder of the day. With the approaching trough there was increasing middle and high cloud. Skies became overcast early in the afternoon. Rain commenced late in the evening. Temperatures ranged from the high thirties to a low of about thirty. Seas increasing to 2 — 3 feet.

Monday, March 30

The low in Labrador continued to move northeasterly at 25 knots while the low off Norfolk moved northeasterly at 40 knots passing about 150 miles south of Sable Island in mid morning. As the trough connecting the two lows passed through Chedabucto Bay around 0300 hours the wind backed to easterly 15 knots and backed further to northerly 20 — 25 knots by noon. Rain changed to snow around 0300 hours and ended by mid morning. The skies slowly cleared. Temperatures remained quite steady in the low thirties. Sea and swell 6 — 8 feet by afternoon.

Tuesday, March 31

The low centre south of the area continued eastward as a high pressure on a N-S line drifted through the Maritimes. Winds decreased quickly after midnight and remained light for the rest of the day. Except for cumulus development in the afternoon the skies remained clear. High temperatures were in the low thirties and the lows were in the low twenties. Seas moderated to 3 — 5 feet.

Wednesday, April 1

The high pressure area continued to move east through Newfoundland and out to sea as an intense low centre moved east from Norfolk, Virginia. Winds increased to easterly 15 knots early in the day and backed to north northeasterly by afternoon as the low centre moved east of the area. Skies were mainly overcast with occasional snow showers. Clearing had occurred by evening. Temperatures ranged from the mid thirties to a low in the mid twenties. Seas remained 3 — 5 feet.

Thursday, April 2

A broad ridge of high pressure moved eastward through the Maritimes as an intense low moved ENE across Lakes Erie and Ontario. Light winds and scattered cloud prevailed most of the day however by late evening the winds had increased to southeast 20 — 25 knots. Temperatures were in the low twenties by night and highs during the day in the mid thirties. Sea state was slight increasing to 3 — 4 feet in the evening.

Friday, April 3

The low from the Great Lakes continued eastward and by 1200Z it was located near Caribou, Maine and from there it moved ENE at 15 knots during the day. At 1200Z a trowal structure extended from the low centre through Halifax and this moved east through Chedabucto Bay at 1500Z. The winds increased to southeast 34 — 40 knots shortly after midnight and then veered to southwest 30 knots with the trowal passage and continued southwest 30 for remainder of the day. A short period of freezing rain around midnight gave way to rain and fog which continued until 1100Z. After 1100Z the rain tapered off to a few showers which in turn changed to snow showers late in the day. High temperatures were in the low forties and lows near 32. Sea state increased to 10 — 12 feet.

Saturday, April 4

The storm continued to move ENE over the Gulf of St. Lawrence and northern Newfoundland. The winds slowly veered and decreased from southwest 30 to west 20 – 25 knots by evening. Skies were partly cloudy as the snow showers ended in the early morning. High temperatures were near 35 and lows near 30. Sea states decreased to about 6 – 8 feet.

Sunday, April 5

The storm curved northward and moved slowly along the Labrador coast. Winds continued to veer slowly from west 20 – 25 knots to northwest 20 – 25 knots by evening. Skies were mainly clear except for some cumulus development in the afternoon. High temperatures were near 35 and lows near 25. The sea state was 5 – 6 feet.

Monday, April 6

The storm continued slowly northward along Labrador as a small high pressure centre moved eastward from New York and passed south of the region. Winds continued from northwest however they had weakened to 10 – 15 knots by daybreak. Skies were mainly clear. High temperatures were near 35 and lows near 25. Sea state was down to 3 – 5 feet.

Tuesday, April 7

The high to the south was followed by a storm centre moving slowly ENE but passing well to the south of Chedabucto Bay. A second low moved ENE along the St. Lawrence River. Winds were light and variable for the early part of the day but by mid morning they had increased to easterly 10 – 15 knots. There was increasing high cloud throughout the day and it became overcast late in the afternoon. High temperatures were around 35 and lows near 25. The sea state was slight but it increased to 3 – 4 feet in the evening.

Wednesday, April 8

One storm passed about 350 miles south of Chedabucto Bay early on Wednesday and curved ENE toward Cape Race and the second low along the St. Lawrence weakened rapidly. Winds were east 15 knots early in the day but backed quickly to north 30 shortly after daybreak and backed further to northwest 30 in the afternoon. Skies were overcast all morning but cleared rapidly in the afternoon. High temperatures were around 35 and lows near 30. Sea state was 8 – 10 feet in the morning subsiding to 4 – 6 feet by evening.

Thursday, April 9

The low near Cape Race continued northeastward and another low was approaching the Maritimes from Northern Ontario. The wind was northwest 25 – 30 for the most of the day but was beginning to weaken late in the day. Skies were mainly clear with some high cloud drifting in late in the day. High temperatures were near 35 and lows near 25. Sea states were 4 – 6 feet.

Friday, April 10

Two weak lows were rotating through the Maritimes around a larger low which was centered east of Newfoundland. The winds in the bay were northwesterly 15 knots throughout the day with sunny skies prevailing. Temperatures were in the mid thirties. Sea slight.

Saturday, April 11

The two weaker lows had joined with the larger low forming a complex low to the east of Newfoundland. This left the bay in a light northwesterly flow but by afternoon winds had increased to 20 – 25 knots from the same direction. During the night some light snow fell and occassional drizzle occurred during the day. Flying conditions were marginal at times as fog and low cloud rolled down the bay. Sea slight.

Sunday, April 12

The complex low continued to dominate the winds. A strong north to northeast gradient persisted over the Maritimes giving winds up to 25 knots in the bay. The morning began with overcast conditions but this gave way to scattered conditions in the afternoon. Flying conditions were fairly good although there was some moderate to heavy turbulence reported near the hills. Temperatures were in the low thirties overnight but reached the low forties in the afternoon. Seas 2 – 3 feet.

Monday, April 13

The northerly gradient continued over the maritimes as the complex low pressure system became quasi-stationary well out into the Atlantic Ocean. The northwesterly winds increased to a maximum of about 35 knots out in the bay by afternoon. Four foot waves were reported at Cerberus rock. It was generally overcast with a few sunny periods and some rain and snow shower activity during the day. Temperatures ranged from the low thirties in the early morning to the high thirties late in the afternoon.

Tuesday, April 14

The complex low system began to move out further into the Atlantic and a strong ridge oriented northwest to southeast began to dominate the weather late in the afternoon. Winds were northwesterly 15 – 20 knots during the day but dropped off sharply in the late afternoon. Skies were sunny and a maximum temperature of 40 was reached. Seas decreased to 1 – 2 feet.

Wednesday, April 15

As the high pressure area moved slowly across the Maritimes some early morning fog was experienced. Winds were light and from the south, bringing in fog to the mouth of the bay in the late afternoon. Temperatures ranged from a low of 30 to a high of 43.

Thursday, April 16

The ridge, building a little overnight, was centered over the Gulf of St. Lawrence during the day causing a light southeasterly flow over the bay. Flying conditions were below limits with visibility less than one half a mile in fog until after 1000 hours. Temperatures remained fairly constant in the low thirties.

Friday, April 17

Overnight the high pressure area weakened as a low pressure centre and frontal system moved in from Quebec. Thick fog developed reducing visibility to less than a quarter of a mile. By 1100 hours the fog cleared and visibility became good. Winds were southeasterly 10 – 15 knots during the day with temperatures ranging from a high of 40 over the land to the low thirties over the bay.

Saturday, April 18

As the low in Quebec moved slowly northeastward, an intense low to the east of Bermuda began curving northward forming a cold over Chedabucto Bay. Some early morning stratus broke up around 1000 hours leaving scattered cloud for the rest of the day. Winds were predominately southeasterly 10 – 15 knots. Temperatures in low

thirties in the early morning rose to the high thirties in the afternoon. Slight sea and swell.

Sunday, April 19

By morning the Quebec low had merged with the intense low from the Atlantic just south of Newfoundland. As the cold front passed during the early morning hours the bay came under a moderate northerly flow. Conditions ranged from good flying conditions in the morning to below limits in the afternoon. Visibility was reduced to less than half a mile in drizzle, fog and snow flurries. Winds were northwesterly 25 — 30 knots in the entire bay area. Temperatures ranged from the low thirties to the mid thirties. Sea 2 — 3 feet.

Monday, April 20

The combined low centre slowed down over eastern Newfoundland and began moving northeasterly into the Atlantic late in the day. The bay remained in the moderate northerly flow until late in the day when a weak ridge moved into the area. Some early morning snow reduced visibility to 2 — 3 miles, but this changed into snow flurries by 0900 hours. Winds were northwesterly 30 — 35 knots in the morning and shifted to northerly 25 knots in the afternoon and further to northerly 15 knots in the evening. By the afternoon seas in the bay were up to 4 feet high. Temperatures were in the low to mid thirties.

Tuesday, April 21

Partly cloudy in the morning, a broken altocumulus, which disintegrated after noon-hour. There was no precipitation and temperatures ranged from a morning minimum of about 30°F to a maximum of about 42°F. Winds were northwest through the day, eight knots by morning, and 10 — 15 knots during the afternoon. Sea heights in the bay were a maximum of 1 ¼ feet.

Wednesday, April 22

Sunny skies at dawn gave way to cloudy afternoon skies (broken to overcast altocumulus). Calm morning winds increased to southeast at 10 knots. Clouds generally broke up again with sunset. Temperatures ranged from 28°F to about 42°F maximum. Light seas prevailed in Chedabucto Bay.

Thursday, April 23

A ridge of high pressure well west of the region, having now persisted for two days, gave sunny skies all day; southeast winds of 10 knots flowed across Chedabucto Bay, while the higher pressure westward funnelled a 10 — 15 knots northwest wind through the Strait of Canso and Port Hawkesbury. Temperatures ranged from 28°F (approx) to 40°F. Seaheights were 1 — 2 feet.

An interesting addition to the day's weather was the formation of fog or low stratus over the ice floes north of the Canso Causeway when afternoon temperatures and dew points reached 38°F and about 33°F respectively. Obviously the stratus formed from surface cooling, dissipating by convection as it moved over land, and also in the region of wind convergence near Port Hawkesbury. With night-time cooling of both temperatures and dew points the stratus completely dissipated by 2100 local time.

Friday, April 24

Clear skies at sunrise, with high clouds (cirro-stratus and altocumulus) generally increasing from the southwest through the day. Approaching dusk, these thickened and lowered, while visibilities, which had been unlimited all week, lowered slightly to six miles in haze. Calm morning winds picked up to south-southeast at 12 knots during the afternoon. Seas in the bay were 1 — 3 feet.

Saturday, April 25

Most of the day was cloudy with southerly winds of 20 – 30 knots. Light rain began just after 0600 local time, became moderate to heavy in the late morning when ceilings dropped to one to two hundred feet, visibilities to ¼ to one mile. Passage of a trowal resulted in a change to drizzle around 1330 local, ending by 1500, a total fall of .75 inches being recorded at Canso. A cold frontal passage around 1700 gave a very light shower, and winds changed to northwest at 10 knots while skies cleared rapidly. Temperatures were 35°F in the morning, 45°F in the afternoon.

Sunday, April 26

Skies were sunny with only a few clouds. Light westerly morning winds increased to northwest at 20, gusting to 30 knots during the afternoon. Temperatures rose rapidly from a sunrise minimum of about 30°F to the mid fifties.

Monday, April 27

Sunny skies, a sunrise minimum near 32°F, and light winds, quickly gave way to broken cumulus clouds, 50 – 60 degree temperatures, and gusty southwesterly winds of 15 to 30 knots. Showers, at times moderate, commenced around 1100 local, and ended in the early evening after the passage of a small disturbance which had moved steadily across northern Nova Scotia during the day. A total precipitation fall of .05 inches was recorded at Canso. Northwest winds of 10 gusting 20 knots followed the passage of this disturbance, becoming light (five knots or less) after dark.

Tuesday, April 28

Variable cloudiness, clearing by late afternoon. Morning winds were west at 5 – 10 knots, increasing during the afternoon to westsouthwest at 10 – 15 knots, except at Port Hawkesbury where the Strait of Canso funnelled northwest winds of 12 gusting 20 knots. Temperatures were in the low thirties at dawn and reached the low fifties by mid-afternoon.

Wednesday, April 29

Sunny skies persisted through the daylight hours. Light westerly morning winds increased before noon-hour to 20, gusting to 35 knots, diminishing slowly after maximum temperature time. A morning minimum of about 30°F increased only to the high forties by mid-afternoon.

Thursday, April 30

Scattered high cloud, wind N.W. 15 with gusts to 20. Occasional gusts in the straits to 24. Temperatures: max 47, min (Thursday morning) 30.

Friday, May 1

Scattered variable broken middle and high cloud. Wind 290 at 10 – 15 before noon, backing to 240 at 18 – 31 by 18Z. Wind became 240 at 12 by 20Z. Temperatures minimum 32 degrees overnight and climbed to 71 degrees maximum by 1500 local.

Saturday, May 2

Scattered high clouds. Wind W.N.W. 15 maximum gusts 22. High of 83 low 55 degrees overnight.

Sunday, May 3

Minimum 51 degrees, maximum 69 sunny before noon; 1500 broken cumulus at passage of front 1400 local, overcast with showers and fog after 1700 local. Wind: N.W. 10 – 15 maximum gusts to 18.

Monday, May 4

Stratus and fog during early morning, fog lifting by 0900 local, stratus lingering all day. Broken high cloud. Wind: N.W. 5 — 10 knots. Temperatures low 36 and 55 high.

Tuesday, May 5

Rain and fog in morning and early afternoon, occasional drizzle. Rain ending by 1500 local, fog patches continuing. Minimum temperature 36 maximum temperatures 45. Wind: N.E. 10 backing to N.E. 12 by evening.

Wednesday, May 6

Fog in the morning, becoming scattered occasional broken middle and high cloud by 1300 local. Temperatures: minimum 39 maximum 49. Wind: S.E. 15 maximum gusts to 23.

Thursday, May 7

Fog and low stratus, clearing by 1700 local. Light drizzle in the morning. Winds generally south east 5 — 10 ict.

Friday, May 8

A weakening surface low drifted slowly northward across the Gulf under an upper center leaving the local area in a moderate swly flow. Surface gradient winds were 30 knots. Reported lighthouse winds averaged 15 knots except Green Island consistently reported winds 20 — 25 knots. SC cloud with embeddedCU + gave occasional showers to the area but no restrictions to visibility were noted. Radar echoes of broken showers were moderate in intensity. The Chopper reported moderate to severe turbc especially in the channel all day.

Saturday, May 9

A weak trowal moved across the area this morning. It was embedded in a trof which moved around a filling low in southeast Labrador and carried along with it overcast middle cloud and broken SC cloud and it gave an occasional shower. These showers did not restrict visibility. Broken SC followed behind and it slowly became scattered near the end of the day. The surface gradient wind was swly at 28 ahead of the trowal and wly 20 behind. Local winds for all areas were swly 15 in the morning. After tropa local winds veered to the NW at generally 13 knots except at Eddy Point and Port Hawkesbury which showed a marked channeling effect giving winds approx 18 knots. There was little or no turbc in the Chopper except occasionally light in the center of the channel.

Sunday, May 10

A ridge passed through the area during morning but an approaching warm front through Nantucket spread middle cloud some distance beyond the ridge line giving mainly a cloudy day. This middle cloud gave an occasional very light rain shower in the afternoon but no restrictions to visibility were reported. Reported winds were swly and light. Although fog was moving up the coast, Eddy Point reported a clear horizon in the early evening.

Monday, May 11

A weak frontal disturbance moved just to the north of Cape Breton today putting the area in the warm sector for the morning. Fog was extensive but in the absence of middle cloud in the warm sector, it burned off the land quite rapidly but it remained in the channel all day although it was less dense at the time of maximum heating (VIS 3 miles). Winds in the warm sector were reported to be swly at 8. At noon the cold front started pushing through accompanied by a wind shift to westerly and noticeably cooler tempera-

tures. The sky gradually clouded over and light rainshowers commenced in the late afternoon. Before the rain started winds were reported westerly around 20 for channel stations and around 10 for open bay stations. The mist was noticeably denser in front of the hill by Mulgrave possibly due to mechanical convergence.

Tuesday, May 12

A weak but active wave passed south of Yarmouth towards Sable Island today. Its 15Z position was 100 west of Sable. The amount of rainfall from the over running reported at Canso at 18Z was .58 inches. NS cloud was based at about 500 feet and visibilities were generally 2 miles in light and occasionally moderate rain. Winds were light ely for all reporting stations as the storm was poorly developed and had no upper support.

Wednesday, May 13

A weak ridge passed quickly over the area after yesterdays disturbance. At mid morning a weak flow from the SE was again established to add to the tremendous amount of moisture in the lower 3000 feet of the atmosphere. Surface heating succeeded in lifting the ceiling to 600 feet and visibilities improved to 4 miles. The fog moved back in late afternoon. Storm that was near Burlington in the morning was developing and moving towards Halifax. Rain commenced in the late afternoon increasing the ceiling and visibility in the fog. Winds in the afternoon were SE at 10.

Thursday, May 14

Another weak disturbance passed south of Nova Scotia last night. 141800Z position of the disturbance was 60 E of Sable Island. Overcast stratus based around 600 feet occasionally 200 feet lingered behind the disturbance in the light n'ly flow. In the late afternoon the tight gradient of a building Hudson Bay high reached the area and winds very suddenly backed to north west and increased to 15 gusting to 18 in the channel. The stratus dissipated to a scattered condition quite rapidly but remained broken over the channel again the evening.

Friday, May 15

Scattered cumulus cloud, winds NW 15, max gusts to 26. Max Temp. 50.

Saturday, May 16

Clear, winds NW 10, backing to SW 10 by mid afternoon. Overnight low 28, max. 50.

Sunday, May 17

Cloudy early morning, becoming partly cloudy by mid morning. Winds south 20 gusting to 30. Overnight low 47, max 55.

Monday, May 18

Rain and fog in the AM, overcast the rest of the day except for the occasional break in between 1600 and 1800. Fog and stratus again in the evening and at night. Winds 46 to 53 from SE.

Tuesday, May 19

Fog in the morning, occasional break in overcast during the day, fog in the evening, occasional light rain after 1800. Winds SE 13 gusting to 16. Temperature 47 and 55.

Wednesday, May 20

Overcast stratus, visibility 3 miles in AM, improved in the afternoon. Winds SE 5 – 10 knots. Occasional break in overcast late afternoon. Temperature 45 and 55.

Thursday, May 21

Low stratus in the Strait in the morning, becoming sunny by 1100. Winds NW 10 – 20 max gusts to 30 knots. Temperature 40 and 50.

Friday, May 22

Sunny until 1100, calm winds in the morning, becoming south 12 gusting to 16 by 1800. Showers beginning 1400, continuous rain beginning near 1800. Temperature 37 and 50.

Saturday, May 23

Overcast low stratus, occasional fog patches in the morning, becoming sunny by 1500. Winds NW 13 gusting to 22 knots. Temps 43 and 54.

Sunday, May 24

Scattered clouds except cloudy during frontal passage at 1100. Winds NW 15 gusting to 33 knots AM, N 18 gusting to 30 knots in afternoon, Temps 40 to 55.

Monday, May 25

Sunny in the morning, becoming overcast middle cloud by 1500, winds NW 10 gusting to 16, becoming SE 10 by 1600. Temps 35 and 50.

Tuesday, May 26

Rain and fog all day, winds South 10 gusting to 16 knots with occasional breaks in clouds in the evening. Temps 46 and 51.

Wednesday, May 27

Rain and fog all day. Winds WSW 12 gusting to 24-27. Temps 46 and 51.

Thursday, May 28

Some low stratus and fog in the morning, clearing by 1000. Partly cloudy the rest of the day. Winds NW 15 – 20 gusts up to 28 knots. Temps 47 and 55.

Friday, May 29

Sunny and cool, winds NW 15 kt Max. Temps 33 and 55.

Saturday, May 30

Sunny and cool in the morning. Winds S 5 – 10 Kt. Temps 34 and 57.

Sunday, May 31

Large high pressure to the south with a frontal system pushing south through Quebec and Labrador. Winds were SW 20 – 25 Kts with increasing cloud throughout the day. Temperatures were near 50 in the morning rising to the low seventies in the afternoon.

Monday, June 1

Frontal system continued south through New Brunswick and Nova Scotia and stalled over southern Nova Scotia late in day. Extensive coastal fog during the day was mixed with showers in the morning. Winds shifted quickly to NE 15 – 20 Kts with the frontal passage in the early morning. Temperatures were steady in the low fifties throughout the day.

Tuesday, June 2

Frontal system began moving toward the NE and passed through the area around noon. Winds were 10 – 15 Kts and steadily veered from NE through SE to SW with frontal passage. Continuous rain and fog in the morning but in the afternoon the rain stopped and extensive coastal fog continued. Low near 40 high near 50.

Wednesday, June 3

The warm front continued toward the NE but a cold front began sweeping southward through New Brunswick. Winds were SW 20 Kts increasing to SW 25 – 30 Kts in the afternoon. Extensive coastal fog persisted, however visibilities did improve to 4-5 miles as the strong winds lifted the fog producing a stratus layer during the afternoon. Low temp in the high 40's and high in the high 50's.

Thursday, June 4

The cold front continued southward and passed through the area shortly after midnight. Overcast with showers in the early morning, cleared by noon. Winds veered to NW 10-12 Kts with frontal passage. Low temperature in mid 40's and high near 60.

Friday, June 5

The cold front pushed further south and the region was dominated by a weak ridge extending SW from a high pressure area over Newfoundland. Light winds and scattered cloud prevailed except for a few patches of early morning fog. Low temperature in the low 30's high in the low 50's.

Saturday, June 6

The high drifted eastward as a low slowly approached the Bay of Fundy from the Nantucket area. Winds increased to easterly 15-20 Kts. Skies were overcast and rain drizzle began near noon with reduced visibilities. Temperatures were steady in the low 40's.

Sunday, June 7

The low with an associated frontal system continued NE through the Gulf of St. Lawrence and a second low developed near Nantucket. Winds steadily verred to south 15-20 Kts by daybreak and to SW 15-20 Kts by noon. Rain ended in the morning but drizzle and fog continued throughout the day. Low temperature in the low 40's high in the mid 50's.

Monday, June 8

The low from Nantucket moved NE passing just south of Nova Scotia and to the east of Chedabucto Bay about 1500. Drizzle, fog, showers and the occasional thunder storm lasted through most of the day but clearing began in the early evening. Winds were light southerly through most of the day but veered and increased to NW 10-15 Kts after 1500. Temperatures were steady in the low 50's.

Tuesday, June 9

The low continued past Cape Race Nfld, and a weak ridge passed over the Maritimes. The day saw only scattered cloud and excellent visibilities. Winds were WSW about 5 Kts in the morning but increased to 15 Kts in the afternoon. Low temperature in the mid 40's high in the mid 70's.

Wednesday, June 10

A trough and frontal system pushed down through Quebec and lay on an east-west line through the Gulf of St. Lawrence and the northern part of Newfoundland. Again there was only scattered cloud but visibilities were restricted to 5-6 miles in haze and fog over the sea and fog moved inland at night. Winds were 25-30 Kts from the SW during the day but dropped to SW 10-15 Kts at night. The overnight low was near 50 and the high temperature near 70.

Thursday, June 11

The frontal system pushed slowly south then became stationary on an E-W line through Grindstone Island. A low moved eastward into the Gulf from Quebec. Thick fog persisted along the coast throughout the day whereas inland there were scattered clouds and some mist patches. Winds continued SW 15-20 Kts. Low temperatures were in the high 40's and high were near 60 near the coast and in the 70's inland.

Friday, June 12

Overnight the low moved northeastward through the Gulf of St. Lawrence pushing the cold front through Cape Breton clearing the fog. Winds veered from SW to NW at 15 Kts. Visibilities improved from less than a mile to greater than 10 miles overnight. Temperatures ranged from mid 40's to mid 50's.

Saturday, June 13

As the cold front moved southeastward into the Atlantic a high pressure area began moving slowly southeastward from James Bay. With a very weak pressure gradient winds were variable and light. Some early morning coastal fog moved out as the winds became steady from the north at 10-15 Kts. Scattered showers were reported with skies being mainly cloudy. Temperatures were cooler with the low being near 40 and the high near 50.

Sunday, June 14

Skies were mainly clear by early Sunday morning and remained so all day as a ridge of high pressure drifted SE over the Maritimes. Winds were NW 10 Kts in the morning slowly backing through the day to SW 15 Kts. Overnight low temperature near 40 and the high near 60.

Monday, June 15

The high pressure ridge continued to drift slowly SE away from the Maritimes and aside from scattered cloud there was no significant weather. Winds were light overnight but increased to SW 15 Kts Monday afternoon. Overnight lows in the mid 40's and afternoon highs in the high 60's.

Tuesday, June 16

The high became almost stationary to the south of Nova Scotia and a weak trough moved south into the Gulf of St. Lawrence which caused a much stronger pressure gradient over the region. Tuesday saw only scattered cloud, however, the winds increased steadily to become SW 30-35 Kts by afternoon. Low temperatures were near 50 and highs were in the low 70's.

Wednesday, June 17

The trough through the Gulf of St. Lawrence weakened rapidly early Wednesday and, consequently, the winds also. The southwesterly flow continued and the moisture of the airmass increased causing fog banks along the coast by Wednesday evening. Winds were SW 10-15 Kts. Overnight lows were near 50 and highs near 70.

Thursday, June 18

The southwesterly flow continued and fog along the coast was extensive on Thursday with visibilities and ceilings near zero all day. Over inland areas broken cumulus had developed by afternoon and a few showers were reported. Winds were SW 5-10 Kts during darkness but SW 20-25 Kts during the day. Early morning low temperatures were near 50 and highs were near 60 along the coast but in the 70's inland.

Friday, June 19

A low pressure centre moved slowly along the St. Lawrence River towards the Gulf and a warm front moved NE through Nova Scotia. Extensive coastal fog and drizzle continued and there was also shower activity on Friday afternoon. SW winds 10-15 Kts during the day. Overnight lows were near 50 and highs were in the low 60's along the coast and in the 70's inland.

Saturday, June 20

As the low pressure persisted over the northern Gulf of St. Lawrence an increasing southwesterly gradient continued over the area. Fog and light drizzle continued throughout the day. Winds were SW 15-20 Kts, lighter at night. Highs were in the mid 50's and lows in the low 50's.

Sunday, June 21

A cold frontal passage early Sunday morning brought an end to the overcast skies, showers and fog on the first day of summer. Winds remained westerly 15-20 Kts during the day and light at night. Under sunny skies temperatures climbed to the low 60's and dropped to the low 50's overnight.

Monday, June 22

A weak westerly flow continued over the area giving SW winds 10-15 Kts during the day and light at night. However mainly cloudy skies were the rule with highs in the low 60's and lows in the low 50's.

Tuesday, June 23

A low pressure system moving eastward from Nantucket maintained mainly cloudy skies with fog developing in the afternoon and evening. An instability line from New Brunswick brought evening thunder showers and fog to the area. SW winds 15 Kts by day dropped to light at night. Temperatures were in the upper 50's and overnight lows in the low 50's.

Wednesday, June 24

A light to moderate southwesterly flow continued during the day. Overnight fog with temperatures in the low 50's were relieved by sunny afternoon skies and temperatures in the mid 60's. Fog patches along the coast persisted and moved inland in the evening. Southerly winds 10-15 Kts continued.

Thursday, June 25

The moderate southwesterly flow continued and the fog kept temperatures in the low to mid 50's overnight and during the day. Winds SW 20-25 Kts dropped to light westerly in the evening as a weak cold front crossed the area.

Friday, June 26

A light variable flow in the frontal zone kept skies mainly cloudy with temperatures climbing to the low 60's and overnight lows in the upper 40's. Again fog moved into the Chedabucto Bay by evening under light southerly winds.

Saturday, June 27

A low developed in Pennsylavania and moved northereastward along the fronts stretching from Nantucket through Sable Island eastward. Light southwesterly winds, thick coastal fog and temperatures near 50 in the morning were replaced by southeasterly winds 20-25 Kts, rain and fog and temperatures near 60 in the afternoon and evening.

Sunday, June 28

As the low tracked northeastward through Newfoundland, the area experienced a cold frontal passage early Sunday morning. Overcast skies with rain, drizzle and fog, temperatures in the low 50's were the rule in the morning. Afternoon temperatures were only in the mid 50's under cloudy skies and NW winds of 15 Kts. However clearing occurred in the evening.

Monday, June 29

Under clear skies and light winds overnight temperatures dropped to the mid 40's. But temperatures recovered to the low 60's under sunny skies and light southwesterly winds.

Tuesday, June 30

The light and moderate southwesterly flow continued over the area. Overnight temperatures were near 50 and afternoon readings near 60. Mainly sunny skies predominated though some showers were experienced in the evening. Light winds overnight picked up to southwesterly 15-20 Kts during the day.

ATTACHMENT B

Date	Time	Observed Wind (Canso Light) kt.	Geostrophic Wind kt.	Weather (Canso)	Vsby	Tmp °C
1970 Feb. 4	00Z	180/20	200/60	Overcast.	8 mi.	+ 5
	06Z	140/30	180/65	Overcast.	8 mi.	+ 6
	12Z	180/25	200/70	Overcast.	8 mi.	+ 6
	18Z	170/30	190/65	Overcast.		6
Feb. 5	00Z	140/30	190/70	Overcast.	5 mi.	+ 4
				Cold FROPA Canso approx 0130Z.		
	06Z	200/25	250/35	Overcast.	8 mi.	+ 1
	12Z	320/20	320/20	Broken	10 mi.	- 2
	18Z	160/10	030/10	Overcast.	15 mi.	- 3
Feb. 6	00Z	040/05	040/10	Overcast.	15 mi.	- 3
	06Z	040/10	040/10	Overcast.	15 mi.	- 3
	12Z	040/10	060/15	Overcast, ZL-.	4 mi.	- 3
	18Z	040/05	040/20	Overcast, ZL-.	4 mi.	- 1
Feb. 7	00Z	030/10	030/20	Overcast, ZL-.	8 mi.	0
	06Z	040/05	030/25	Overcast.	10 mi.	- 2
	12Z	350/05	020/20	Broken.	10 mi.	- 3
	18Z	360/05	020/20	Overcast.	15 mi.	- 1
Feb. 8	00Z	030/10	030/15	Overcast.	10 mi.	- 1
	06Z	350/05	030/25	Overcast.	10 mi.	- 2
	12Z	020/05	020/20	Overcast.	10 mi.	- 3
	18Z	320/05	010/10	Fog, clr.	3 mi.	- 1
Feb. 9	00Z	320/05	360/15	Fog, clr.	5 mi.	- 3
	06Z	330/05	350/15	Clear.	10 mi.	- 3
	12Z	330/05	010/05	Clear.	10 mi.	- 4
	18Z	330/05	360/05	Sctd, fog.	5 mi.	+ 1
Feb. 10	00Z	360/05	360/05	Clear.	8 mi.	- 3
	-6Z	340/05	360/05	Obscd, fog.	¼ mi.	- 3
	12Z	180/05	180/05	Ovc, fog.	3 mi.	- 2
	18Z	180/05	180/05	Ovc, fog.	4 mi.	- 1
Feb. 11	00Z	130/05	150/20	Overcast.	8 mi.	- 1
	06Z	110/10	130/30	Broken.	10 mi.	0
	12Z	090/20	130/50	Broken.	10 mi.	+ 1
	18Z	130/30	130/75	Ovc, L-.	5 mi.	+ 2
Feb. 12	00Z	100/15	130/50	Overcast.	5 mi.	+ 4
	06Z	160/10	220/30	Obscd, fog.		+ 2
	12Z	190/20	240/40	Rain, fog.	1 mi.	+ 2
	18Z	220/20	240/35	Brkn, fog.	6 mi.	+ 2
Feb. 13	00Z	220/25	250/35	Overcast.	10 mi.	+ 1
	06Z	260/20	290/30	Overcast.	15 mi.	- 1
	12Z	200/10	270/20	Clear	15 mi.	- 7
	18Z	250/15	260/15	Overcast,	2 mi.	0

				snowflurries.		
Feb. 14	00Z	250/05	260/05	Overcast.	15 mi.	- 3
	06Z	340/20	350/25	Overcast.	15 mi.	- 6
	12Z	250/05	300/30	Sctd.	15 mi.	- 12
	18Z	260/15	270/30	Sctd.	15 mi.	- 8
Feb. 15	00Z	260/10	290/20	Sctd.	15 mi.	- 13
	06Z	270/15	280/20	Clear.	15 mi.	- 15
	12Z	250/05	270/10	Clear.	15 mi.	- 15
	18Z	180/05	180/10	Broken.	15 mi.	- 7
Feb. 16	00Z	110/15	130/40	Mdt snow.	½ mi.	- 5
	06Z	090/15	160/30	R-	5 mi.	+1
	12Z	240/30	240/40	R-	3 mi.	+4
	18Z	200/15	280/30	Fog.	3 mi.	0
Feb. 17	00Z	270/25	300/30	Broken.	10 mi.	- 4
	06Z	300/10	300/20	Clear.	15 mi.	- 7
	12Z	270/05	330/10	Clear.	15 mi.	- 10
	18Z	360/05	Light.	Broken.	15 mi.	- 4
Feb. 18	00Z	200/05	160/15	Broken.	15 mi.	- 5
	06Z	070/05	080/20	Clear.	15 mi.	- 6
	12Z	040/10	070/15	Clear.	15 mi.	- 4
	18Z	040/10	060/25	Broken.	15 mi.	- 1
Feb. 19	00Z	060/10	080/20	Overcast.	10 mi.	- 2
	06Z	170/05	Light.	Overcast.	15 mi.	- 2
	12Z	190/15	250/20	Overcast.	10 mi.	0
	18Z	220/5	220/25	Overcast.	10 mi.	+2
Feb. 20	00Z	350/05	010/25	Snow.	2 mi.	0
	06Z	300/25	330/40	Broken.	10 mi.	- 4
	12Z	270/05	300/20	Sctd.	15 mi.	- 10
	18Z	270/05	290/15	Clear.	15 mi.	- 9
Feb. 21	00Z	300/10	320/20	Snowflurries.	10 mi.	- 5
	06Z	320/20	320/35	Sctd.	10 mi.	- 7
	12Z	270/10	330/20	Sctd.	15 mi.	- 12
	18Z	270/10	280/20	Overcast.	15 mi.	- 8
Feb. 22	00Z	310/05	300/10	Sctd.	15 mi.	- 11
	06Z	270/10	300/15	Clear.	15 mi.	- 11
	12Z	270/05	280/15	Clear.	15 mi.	- 12
	18Z	250/15	250/25	Overcast.	15 mi.	- 4
Feb. 23	00Z	200/15	200/30	Snow.	2 mi.	- 1
	06Z	200/10	230/35	Snow.	3 mi.	0
	12Z	200/10	210/20	Rain. Fog.	1 mi.	+1
	18Z	250/10	270/15	Overcast. Fog.	2 mi.	+1
Feb. 24	00Z	270/25	300/60	Broken.	10 mi.	- 7
	06Z	280/25	320/50	Overcast.	10 mi.	- 11
	12Z	270/15	300/45	Broken.	10 mi.	- 17
	18Z	270/20	300/35	Broken.	10 mi.	- 14

Feb. 25	00Z	270/10	300/25	Clear.	10 mi.	- 15
	06Z	250/10	300/20	Clear.	15 mi.	- 16
	12Z	220/05	250/20	Clear.	15 mi.	- 14
	18Z	180/15	180/45	Broken.	15 mi.	0

VOLUME III

PART 3

OIL RECONNAISSANCE

Operation Oil: Some aspects of reconnaissance

by

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Energy, Mines and Resources

Foreword

I arrived at Chedabucto Bay on February 12 as a member of the oceanographic team in CSS "Dawson" and went ashore on February 17 to replace a colleague at Port Hawkesbury who had to leave temporarily. For several reasons I undertook to further the reconnaissance of the distribution of oil and subsequently was asked by the Task Force on its arrival at the site to "maintain and extend the reconnaissance".

There were a number of aspects of the spill which were of interest to me, quite in addition to the fact that it had occurred into the ocean. I had for some time been engaged in study of the water of the Arctic Ocean adjacent to Canada and, with others, was concerned with the possible effects of increased transportation there. As well, I had been associated for about a year with two working groups endeavouring to develop a federal contingency plan for spills of oil and other toxic materials. There was no doubt that a plan was required, but it was becoming apparent, to me at least, that should oil be released to the environment it was only in the unique occurrence that significant limiting action could be taken; the key is to prevent spills.

That the spill at Chedabucto would prove of particular interest became evident soon after our arrival and followed on the observation in "Dawson" of particulate oil at depth in the water column. For me, the interest was sustained throughout, by the wide variety of problems which were encountered by the Task Force and, specifically, by those confronting me.

Introduction

It was part of the function of the reconnaissance to provide a forecast of the distribution of oil at the surface as well as the actual day-by-day distribution. In a qualitative sense this was achieved through one or two helicopter flights each day (about 125 flights were made during the period February 17 to May 7) which provided data for a daily map and hence, part of the basis for prediction. The quantitative distribution of oil within Chedabucto Bay was never determined, so that even by April 24 (Table) considerable doubt existed concerning the amounts which confronted us and hence, about the extent of the problems which the amounts might eventually incur. For example, on April 24 it was estimated that oil was leaking from the wreck at the rate of 5 drums per day (1 drum = 45 imperial gallons) and the evidence of oil at the surface was relatively slight throughout the area. On that day also, it was observed that some re-distribution of oil was occuring in the intertidal zone due to warming of the oil on the shore (most warming occurred during daylight in the absence of cloud and in the absence of wind). It was not known whether this led to significant oil on the surface of the water generally, although in certain local areas, such as southeast Inhabitants Harbour, oil was observed to be moving on the surface from areas of oiled weed. However, in this area it seemed clear that oil was being "contained" by the weed. Oil, as well as oiled weed and oiled debris, were being contained in lagoons, some with significant coupling to the sea only during spring and storm tides, so that it was possible to discern at appropriate stage of tide and with a wind (or no wind) of the right direction, the contribution of this source to the surface outside the lagoon (Plate 1). It was thought unlikely that "Arrow" oil would re-enter the bay from the ocean, so that the only other significant source of Bunker C (by that date) was that at Canso at the apparent leak in the storage tank on shore; on April 24 I estimated this to be about 5 gallons per hour. Nevertheless, the possibility (that "Arrow" oil would enter the bay from the ocean) was always open, as was the possibility that the particulate oil observed at depth might come to the surface. Re-distribution of oil could occur also through movement at the surface of oiled weed and other debris. This was considered a threat to a number of beach areas not yet oiled other than in a minor way. On April 24 a truckload of such material was moved using hand tools (the "slick pickers") from beaches on the Bay of Rocks and machinery (the "slick lickers") was being used effectively in Inhabitants Harbour and Janvrin Lagoon to remove oil and oiled weed. Thus, it seemed to me that with regard to oil still mobile, real progress had been achieved generally. Specifically, it was foreseen that some re-oiling could occur in Blackduck Cove from oiled weed and the heavy accumulation of oil there and on adjacent shores. As well, it was foreseen that oil leaking from the wreck could accumulate at the surface near the site over several days and eventually go ashore. The map for April 24 based on about 4 ½ hours of flight time reflects this concern, as well as the concern about the mobility of oil already on beaches, the operational requirement of cleanup in progress, the attention to proposed cleanup techniques and to problems related to the leak at Canso.

The form and amount of oil

Uncontained oil at the water surface generally took the form of "sheen", "iridescence", "dull" and "chunks" and occasionally "pans". The latter form was seen only at sea after the spill of March 25, although the form is known to have been observed early in the casualty. The few pans seen, occurred separately from the other forms, ie. separate from the larger slicks, and were about 100' – 200' across, about ½"thick and with a dull-black (without luster) and smooth surface.

The "chunk" form was seen early (February 13) in my experience, but not continuously, at the wreck site and referred to pieces of oil, frequently as large as a rolled up

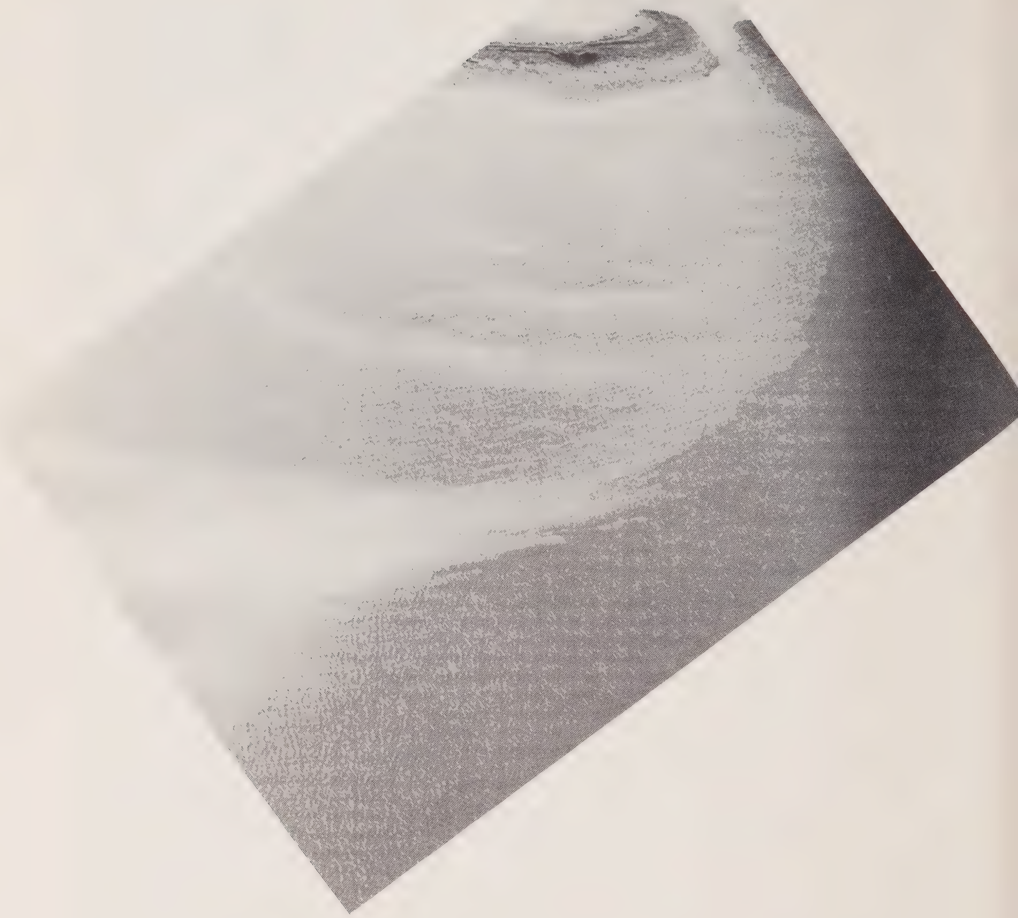

Plate 1. View to the southeast toward north shore of Janvrin Island and entrance to small lagoon after high water. Water is leaving lagoon with oil and oiled debris.

hand-towel, which appeared to be coming from the wreck in the form, but without immediate association with iridescence. Occasionally it was possible to determine that chunks were not being formed at the wreck site, but more often conditions there were such that it could only be said that they were not observed.

At the wreck site we frequently observed a slick with an iridescence which varied from "brilliant" to "dull", but which could generally be described adequately as either iridescent or dull. At some distance from the wreck site the slick or part of it would lose colour and become an area of peculiar surface characteristic (bright, smooth, silvery), which has been called "sheen". Sheen was observed rather widely and in areas, such as nearby lakes, in which we were certain our oil did not exist.

On at least two occasions a material was seen and photographed (but not other wise sampled) in the slick formation close to the wreck which at the time was described as a "red-brown crud" or a "brown crud". It appeared to be a finely divided substance, such as an emulsion of oil or paint, which I thought might represent the material in a tank (fuel, cargo or other) at the interface between the oil and water there.

The variety of the forms of oil seen at the wreck led to speculation concerning the type of oil each form represented, particularly during the early stages of the casualty, and to speculation concerning the amount leaking from the wreck and about the processes which would influence the amount. Data were not obtained relevant to the latter problem; however, the iridescent form was sampled and determined to be Bunker C. As well, the frequent observation of oil in a heavy accumulation streaming away from the accumulation as iridescence dispelled the notion that it was something other than Bunker C.

It seems likely that three major spills occurred prior to about February 13, one at the time of grounding, another when the tanker separated and the third when the stern section sank (about 1030 hours on February 12). We visited the site during the morning of February 13 in CSS "DAWSON" and estimated that oil was escaping at the rate of between 100 to 200 tons per day. At this time the oil was observed to occur in two forms:

> "an iridescent film of little substance and chunks of oil varying from the size of a 50-cent piece to that of a hand-towel rolled up lengthwise; a few pieces as big as a bath-towel rolled up lengthwise."

Subsequently, it seemed noteworthy that the "dull" form was not observed and, in retrospect, it seems that the observation was accurate (the first reference to the "dull" form occurred in early March). I am confident that the "dull" form was not nearly as prevalent at the wreck site during February as it was during March and later. I was never able to determine an obvious correlation between the form of the oil at the surface and other factors except that, as mentioned below, there appeared to be a relation between the quality of the iridescence, almost certainly for brilliant iridescence, and that state of wind and sea. I am also confident that early in our experience the "chunk" form comprised a much greater portion of the oil leaking from the wreck than it did later. Indeed, the estimate of 100-200 tons per day was based entirely on the existence of the chunk form.

The divers' description of the manner in which the oil leaked from small openings in the wreck was of particular interest and, coupled with our observations, indicated that the oil generally surfaced in a discrete piece (like a rope 1 to 2 feet long). In the right circumstances this could lead to a pattern of small discrete slicks in the immediate vicinity; more often the slick from the oil leaking from the bow section exhibited this appearance.

Oil was never contained at the surface at the wreck site so that a relation between the form of the oil and the quantity was not established. Estimates were frequently made, however, based on data in the literature and on estimates of width and of movement of the slick. After the funnel had been removed it was difficult to estimate distances unless there were a ship or buoy in or close to the slick. Usually the examination at the wreck

comprised a close hover up the slick from about 1.5 miles distant from the site as most often a well-defined slick of a least this length existed. Usually, too, there was some movement of the surface water past the wreck, to the eastward*, which combined with a period of no wind and zero sea state, early morning usually, led to the formation of a broad (200 feet) slick of brilliant iridescence. Subsequently, a developing wind would decrease the width near the site and the dull form would become dominant. I decided that, in the circumstances, factors in the existence of the form of iridescence were both wind and wave for it seemed that these led to the formation of persistent local areas of partial containment, which in turn led to changes in the thickness of the oil and hence in the characteristics of the light transmitted (interference bands). As mentioned earlier here, the changes in the quality of the iridescence which occurred as oil moved away from a region of containment in a change of wind direction (or to a calm) were similar to those seen at the wreck.

With a good wind and sea we could not observe the sheen and iridescent forms; apparently these become broken to the extent that they have no visually detectable influence. This seemed to occur at a sea state associated at the wreck site with persistent winds of about 20 knots and, under this circumstance, the slick would appear to be relatively small. At low tide too there was less oil at the water surface and more ashore, so that the combination of a well-developed sea and low tide generally led to the consideration that there was less oil about (than usual).

The area of an accumulation of oil on the water surface, against a shore or in a lagoon, could fairly easily be determined, but the measurement of thickness was never achieved satisfactorily. With experience it was found useful to hover closely over the accumulation so that the oil would move and expose the water surface below, but this was frequently complicated by the existence of an ice cover.

Movement of oil

Most of the movement of oil at the wreck site and throughout the area could be related to surface wind (or what we determined to be the surface wind). The most frequent surface wind was northwest, frequently averaging 20 knots for periods longer than 24 hours. For shorter periods, strong southerly winds and near-calms and an occasional "northeaster" occurred, so that while the oil was moving about within the bay, and was being contained to some extent by shores and in bays, the main movement was to the southeast, out of the bay and away from adjacent shores. The downwind movement of oil away from a shore had a characteristic appearance and was termed "streaming".

Tidal movement could lead to characteristic slick patterns, particularly off entrances to lagoons containing oil, off heavily oiled shores and in apparent regions of convergence (tide lines). In the absence of wind, the movement of oil could occur in discrete pieces or "chunks" with which would be associated discrete areas of iridescence. Such "patchiness" of surface slicks was frequently observed in the Inhabitants Harbour region where the nucleus of each chunk may have been weed, but, as mentioned earlier, the slick at the bow section often exhibited this appearance.

The most frequently observed pattern of oil distribution at the surface in the vicinity of the wreck was a long, narrow slick extending to the eastward from the site in a line about one mile south of Cape Hogan. This pattern was observed in periods of northeast winds and periods of calm or light winds (less than 5 knots), of any direction apparently, and I believe effectively displaced most of the oil from the bay during the days after the

* Oil at the surface moved to the eastward during periods of calm and during periods of appropriate wind ie. westerly and northwesterly. Movement in other directions occurred only when there was a sufficient wind, apparently about 5 knots. I concluded that there was a small residual surface movement to the eastward at the location of the wreck.

casualty. The oil in a spill on March 25 also moved into the ocean in this way, although initially* it moved towards Arichat and a portion caused minor oiling along the east coast of Petit-de-Grat Island due to the southeast winds of March 27.

It was understood that some oil from the tanker had gone ashore at a number of localities including Sable Island . The area of the greatest pollution was, of course, in Chedabucto Bay although smaller areas both immediately north and south of the bay were heavily oiled. Within the bay the oiling varied from very heavy to "trace" only. In the area east of Lennox Passage to just west of Cap Rond and to St. Peters Bay evidence of oil ashore was never seen, although occasionally possible oil at the surface, as "sheen", was observed. Generally the observation of "sheen" or "iridescence" at the surface was the first indication of oil in an area and would lead to checks on the ground for evidence of oil, either as oiled weed or oiled debris or as splashes on rocks or over snow, although snow effectively covered oil at the high tide to storm tide level and at those places where oil was contained by an ice cover. In certain areas (Inhabitants Harbour, Lennox Passage, Haddock Harbour and The Tickle) an existing ice cover appeared to be an effective barrier to the movement of oil. In each area oil in considerable quantity observed at the leading edge of the ice did not seem to move under the ice any significant distance even under persistent wind. Some sampling through the ice and of the ice was attempted on several occasions beginning on February 28 (see later section). Oil in particulate form was observed in the ice (1-2 inches from the underside) and, at some locations, apparently under the ice as well, but in both the amount of oil did not appear large. While this sampling programme was quite inadequate we did continue a careful aerial examination of these areas, particularly during the period the ice covers were weakening, and I concluded that where tidal currents were small an ice cover was (is) an effective barrier. In areas where an obvious tidal current existed, in the entrance to a lagoon for example, the ice cover did not appear to have a limiting effect, although it must reduce the coupling of certain lagoons significantly; as oil is (mostly) at the surface, much would depend on the range of the tide at the time.

Distribution of oil

The distribution on April 24 (Table) of the Bunker C originally in the tanker had, in the time since the casualty, altered considerably in that the major portion is believed to have gone into the ocean. Some of this amount had probably been on shores at some earlier time and was subsequently moved by the action of weathering processes and waves. The particulate oil observed at depth may have been formed by such shore processes, but the amount removed by that date through evaporation are not known; both could be considerable it seems. Many of the terms in the table are complicated because water soon became incorporated into the oil in amounts which could exceed 50%. To what extent the oil in on shore contained water by April 24 was not known. For this reason, as well as the inherent difficulty of such an estimate, little reliance should be placed on the value of 450,000 gallons for this amount beyond about plus or minus 100,000 gallons. The latter consideration does not alter significantly the relative amount of Bunker C believed to have moved into the ocean by this date. As remarked elsewhere, the movement was determined largely by the persistent northwest wind over the area and the existence of a small residual eastward moving current in the near-surface by the wreck site. Under different circumstances, ie. a dominant southerly wind from the southwest+ and the southeast and without the barriers of ice and causeway in Lennox Passage, the amount of oil available could have caused much more serious problems

* The spill occurred about 1600 on March 25 and by 1800 the oil was described from the wreck site as being "directed into Arichat in a long finger".

\+ The average value in May for the occurence of southwest wind is 34% according to information provided on site by the Meteorological Branch.

within Chedabucto Bay generally, including Petit-de-Grat, and caused additional problems in the Bay of Rocks and the shore from Lennox Passage to Cap Rond and St. Peters Bay. That the latter area was never oiled significantly was partly attributable to a general movement of the coastal water to the southwest past Chedabucto Bay. Thus, during much of the time after the casualty to the end of April the combination of northwest circulation (offshore wind), persistent set past the wreck site and persistent coastal current tended to move the oil out of the bay and into the ocean. The oilings within the bay and in the immediate vicinity to the north and south could generally be associated with wind other than northwest.

Oil on Shore

Of considerable interest throughout our time at Chedabucto was the extent to which changes were occuring naturally in the condition of oil on shore. Part of the interest stemmed from the observation programme of "Dawson" which showed, among a number of things, that Bunker C in particulate form occurred at depth; this in turn led to speculation concerning the important processes. While a number of processes appeared relevant those most often considered were (1) wave action on shores and particularly on beaches (2) wave action at sea on oil slicks and (3) the influence of ice and snow on an oil film. The latter idea followed on the observation of particulate oil in association with an ice cover (see next section). On a number of occasions I observed particulate oil in the surf zone off an oiled beach, so that it seemed reasonable that a beach would become relatively oil free through wave action, but the extent was not known. Similarly, slicks streaming off-shore in a wind appeared to be effectively dispersed by wave action, generally within some characteristic distance from that shore.

Early in our observation from the air it seemed too that there was generally less evidence of oil on sand and gravel beaches than on adjacent rocky foreshores; however, ground examination would frequently show that there was considerable oil in the beach material (Plate 2), frequently close to the high and storm tide lines. With time much of this oil was dispersed, apparently into the water, although some oil remained even on the most exposed beach. It was clear that a reduction in the amount of oil was also taking place on rocky foreshores. This seemed to take two forms: (1) a gradual reduction in the amount of oil contained by the roughness of the rock (of any dimension)and (2) a gradual reduction in the amount of oil on the rocks throughout the range of the tide, but greater at the lower tide range. The latter observation is complicated by the observation that there was less oil on shore at the lower limit of the tidal range*. As well, it is complicated by the fact that in some areas a re-oiling occurred which could not be measured; indeed it was difficult, usually impossible to confirm a suspected re-oiling of some rocky shores. While occasionally it was not possible to differentiate a re-oiling of a beach from a re-distribution of oil already on that beach, generally the surface evidence was such that it was possible to "confirm" that an area of beach had been re-oiled. This was partly due to the "self-cleaning" action of an active beach, but it is also due to the fact that beach areas in regions where surface oil persisted were quite clearly receiving and dispersing more oil than adjacent rocky shores. The evidence from the air was that oil would be moved along a previously oiled rocky shore with little re-oiling, to impinge finally on a beach foreshore and to be completely removed from the water. This process seemed to occur with considerable persistence along the shore from Fox Bay to Durell Island and particularly at the beach at Fox Island Main. The impression was that the longshore currents which maintained the beach could lead to a persistent oiling there which oil, in turn, was dispersed relatively quickly by local beach processes initiated by

* A peculiarity of most oiled open shores was that very much less oil occurred between the mid-tide line (mean sea level) and the line of low water than occurred above the mid-tide line; indeed no shore was observed to be oiled to low water of large tides (lower low water). On the other hand, the oiling of some shores was carried to levels above the level of high water of large tides (higher high water), probably by storm effects.

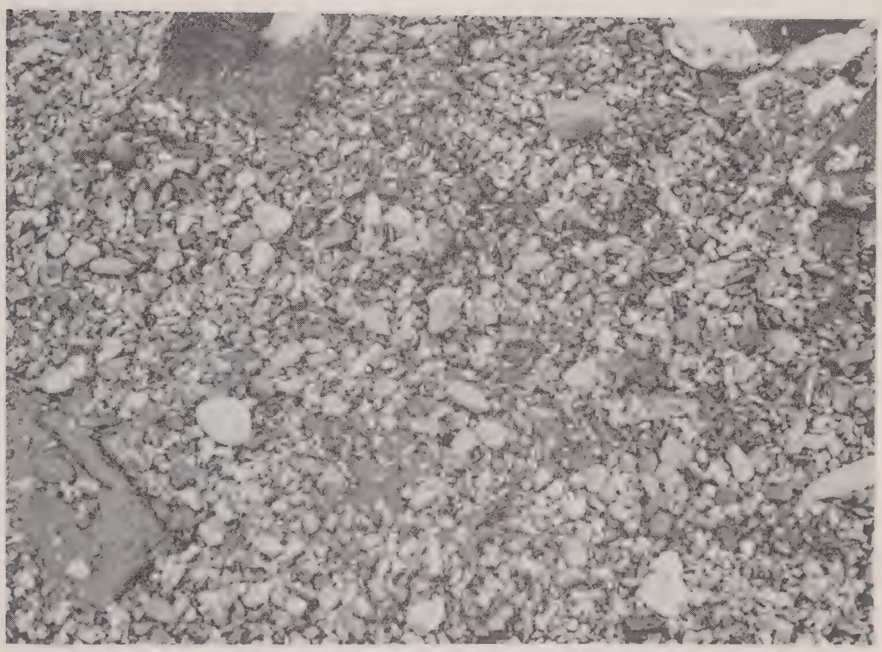

Plate 2. A reproduction of an Ektachrome transparency of a gravel shore on the west side of Durell Island (March 14). At this time the gravel was heavily laced with oil not apparent from the air.

* We soon realized from such considerations that assumptions concerning the amount of oil which a shore had received, or at least the relative amount of oil received by a beach and neighbouring rocky shore were to be avoided. Nevertheless, many of the considerations about changes on shores generally included some tacit assumption about the intensity of oiling and usually that an equal oiling had occurred. The conclusion usually emphasized, rightly, or wrongly, the importance of wave action.

In areas where there was little wave action and a considerable thickness of oil, up to one inch, unmixed with sand and uncontaminated by weed, a portion of the oil would move onto the surface and, with a suitable wind, away from the region. While this process was observed many times it seemed to be of a significant scale on only a few occasions. For example, on April 30 the water on the southeast shore of Blackduck Cove was observed to be extensively discoloured by oil off an adjacent shore. On another occasion in the same general area I observed that thick (one half inch) oil was lifting off sand in rather large pieces (Plate 3) at a number of locations in a relatively small area of this protected foreshore. At the time (May 6) this process appeared to have some relation to the underlying sand, which was in my judgement relatively coarse, and to the relatively warm temperature attained by the oil that day (according to a resident it had been clear, calm and warm most of the day at Blackduck Cove). I deduced that this oil had lifted only hours earlier. I visited the site the next day, but was not able to discern that further lifting had occurred; the day was overcast and cold.

The existence of sand in oiled areas had become of special significance for our observations indicated, (1) that sand with wave and water action effectively moved (abraded) oil from rocky shores, (2) that sand mixed with oil effectively modified the character of this oil (frequently oil was picked up so mixed with sand that it would not adhere to or stain the hand) and (3) that it was possible to stabilize large areas of oil (in sheltered regions) by mixing the quantities of fine sand. An attempt to assess the abrasive action was initiated on March 19 wherein about 150 years of coarse, clean sand and gravel were spread over about 70 yards of a shore of rock outcrop, some large boulders and a beach of sand (on Isle Madame at the seaward side of the Crichton Island jetty in Bonhomme Cove. A somewhat lesser amount of sand and gravel was spread over the shorefront at Lenoir Forge. Both of these areas were subsequently re-oiled (the shore at Bonhomme Cove was re-oiled by floating oil and oiled weed during a period of strong southerly winds of April 3), but it was still possible to observe a decrease in the amount of oil on the shore in each area. At the Bonhomme Cove site much of the sand and gravel put down there was still there on May 7. Under the circumstances this would likely have little bearing on the final result of the "experiment" which, because of obvious limitations, could not be conclusive.

Part of my consideration of the effect on Bunker C of loose material on the shore derived from observations at points where water moved down over the surface of an oiled intertidal zone, directly from a lagoon or from a stream. When this occurred in association with sand and small gravels a distinct surface area free of oil could be observed. At Chedabucto this result, in many instances, occurred quite rapidly in association with the melting snow and ice covers on lakes near the shoreline. Similarly within an intertidal zone where there were areas of accumulation (storage) of sea water which led to small streams down the beach at and close to low water, significant amounts of oil appeared to be moved by the water (Plate 4). Often the oil was so finely divided that it was observed only as a discolouration of the water except at those places where containment occurred. A portion of this oil remained at the water surface or within the surface layer and presumably would be available to oil a shore again. The general process was observed at a number of locations including an area of oiled shore at the

* Fox Island Main beach did receive at least two oilings during storms so that considerable oil was retained at a relatively high level in and on the upper part of the beach beyond the reach of normal wave action.

Plate 3. May 6 at a small indentation in the coastline at the starboard side of the entrance to Blackduck Cove showing an area of sand devoid of oil (with small wooden stake and pocket book matches).

front of the operations center in Canso Strait between Port Hawkesbury and Port Hastings. Here the amount of water moving down the shore was relatively small, but it effectively removed the fine material, ie. sand with oil, from the larger material which made up most of the surface of the intertidal zone there.

Oil and Ice

As indicated earlier, considerable attention was given the possibility that oil at the western edge of the ice "plug" in Lennox Passage would move at the surface under the ice to the eastward. I am confident that this did not occur, for it was only after the plug was dispersed that oil was found in the area, along the west side of the dam in Lennox Passage for example. I concluded that an ice cover is an effective barrier to oil at the surface. It follows too that the ice cover must have been in existence in Lennox Passage by the time that the oil occurred to significant extent in the western part. Similarly, the ice cover must have become established relatively early in Inhabitants Harbour, in parts of the area between east Janvrin Island and west Isle Madame, and in northern Petit-de-Grat Harbour, for in each, a region devoid of oil persisted beyond the time of breakup there. However, these general conclusions are tempered considerably by the observations, described below, which indicate that oil may have occurred in Lennox Passage before the ice cover formed there (if indeed the ice was not advected).

On February 28 a number of holes were chopped in the ice cover of Inhabitants Harbour and Lennox Passage in order to determine whether oil existed at the ice-water interface. At most of these, oil was observed within the ice, but I was never certain whether the oil observed in the hole was in the water or the ice prior to sampling, except that at those sites where oil was not observed in the ice, none* occurred in the water. The oil observed in the water and ice occurred in finely-divided particulate form, reminiscent of that seen earlier in "Dawson," with little or no iridescence. That in the ice occurred (Plate 5) from less than one inch to about two inches from the underside of the ice which was between six to eight inches in thickness. On this day a number of holes were formed in the ice at each of four positions along the centre of the ice plug in Lennox Passage. At one position about mid-way between the east and west edges oil was not observed (although several holes formed), while at another position close to the east edge, oil was observed.

On March 1 a number of holes were formed in the ice at a number of locations immediately east of Janvrin Island where two samples were obtained and returned to base. Generally the ice here appeared to contain considerable snow (this was the explanation for the lack of ice structure) and was described as coarse and grainy, only 2 to 3 inches thick. As well, oil in particulate form appeared to be distributed throughout the material although the distribution suggested that the oil was "migrating" and "accumulating". At the surface of the ice, the oil occurred as accumulations in small depressions containing up to half a cubic centimeter of oil. Some further sampling was attempted in Lennox Passage on March 2 at an area of "dirtiest ice" in mid-channel just east of Glasgow Point; three samples were returned to base for quantitative determination of oil content. My notes indicate that,

> "the air temperature was 26°F and not too unpleasant in the sun. The intent was to obtain a measured amount of ice, about a square foot in area. Sampling was quite difficult as the ice was mushy and the lower layer of ice not as well-defined as observed earlier. Apparently the ice there had absorbed relatively more radiation which in turn had caused some draining through the ice of the oil in distinctive patterns."

* Our sampling technique was based on rather crude instruments which had to be thoroughly cleaned (with gasoline) between each sampling.

Plate 4. Low water at Blackduck Cove and oil in water moving down the intertidal zone being contained by ripples on the relatively flat lower part of the zone (movement from lower left).

We continued surveillance of the ice front noting the position and the grey colour (white to black) and attempted some photography. On March 21, Petty Officer Tom Galley exposed panchromatic, colour and false-colour (without filter) film from a helicopter in areas of particular interest. A positive of certian of the panchromatic exposures is attached. The false-colour transparencies are available here, but the colour renditions* have not been examined. We determined that the ice cover was about 4 inches thick in Lennox Passage (close to the eastern edge), but it was not sufficiently strong to permit further sampling. Oil was distributed within the ice in patches up to 50 feet across within which were surface accumulations of oil 2 to 6 inches in area (Plate 6).

* It is understood that these transparencies are with the Task Force.

Plate 5. Three exposures, numbered 0-039, 0-040 and 0-041 made February 28 of one ice sample obtained in Lennox Passage. Photo 0-039 was exposed after 0-040 and 0-041 and after the ice sample had been sectioned at the change of structure obvious in 0-040 and 0-041; photo 0-039 is of the surface portion at this section. Photos 0-040 and 0-041 are of a clean, fresh, vertical section of the ice sample. The relatively thin ice formation at the eraser end of the pencil is the bottom portion of the ice and comprised a typical ice structure, quite different than the upper portion which was quite friable.

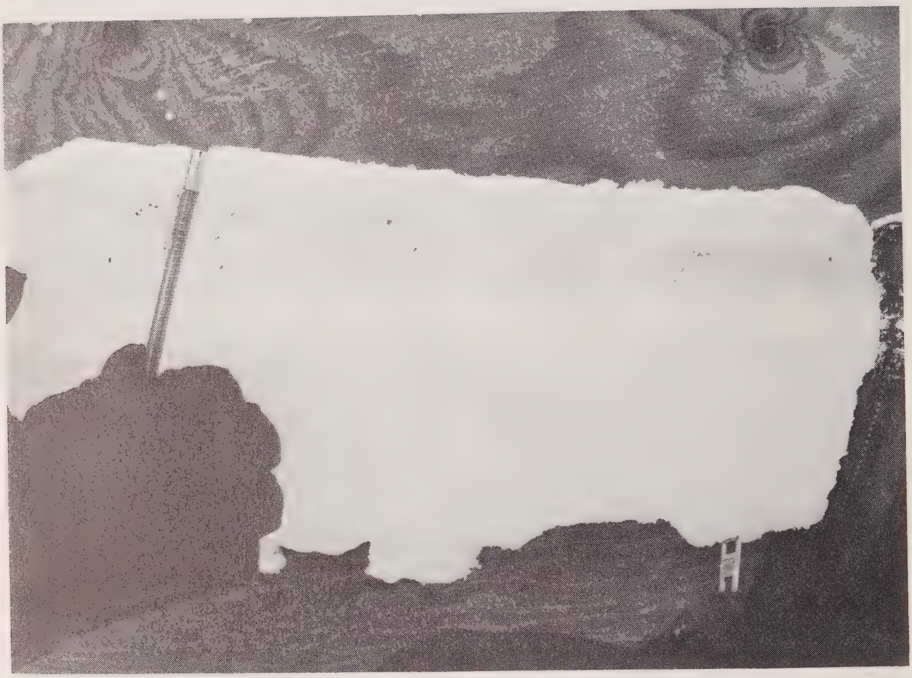

Plate 6. An aerial photo of the surface toward the eastern edge of the ice in Lennox Passage on March 21 (Galley).

Concluding Remarks

In an operational sense it is important that the distribution of the oil in a spill be known at any time and in quantitative terms. This oil budget or balance can provide an important insight to potential problems not otherwise apparent and could determine to considerable extent the nature of the resources required for cleanup. Only a part of the required data would be obtained through aerial observation, but as much of the oil moves at the surface regardless of the source, it is important that determination of the amount be possible from the air. This would require standardization of terms used to describe slicks with an understanding of the relation, for various kinds of oil, between thickness and surface appearance. Eventually it should be possible to map the oil using photographic and similar techniques. It would likely be useful to be able to mark a particular part of a continuous slick, or to mark distinctly a discrete slick, to permit later observation and hence determination of movement. On one occasion at Chedabucto we dropped sheets of bond paper alongside a slick formation and, on this occasion, noted that the movements of the slick and of the paper were not in the same direction. Of course, the paper is soon wetted and does not stay at the surface as does the oil. The trial was complicated somewhat by the problem of jettisoning such material from a helicopter, which could be easily improved, and because a vessel at the site jettisoned an amount of garbage shortly thereafter. This and other forms of possible pollution, of the land as well as the water, some quite persistent, were observed routinely in the area and occasionally photographed. Usually this was accomplished using a small format (35mm) camera and a variety of film. Of this, highspeed Ektachrome film appeared the most useful as it permitted speeds in the helicopter to 1/500th and achieved, what I considered, an adequately accurate rendition. The serious limitation of visual and ordinary photographic reconnaissance is that which occurs at night, unless special techniques are used. The capability for such observation coupled with the ability to provide surface wind data in real time would have been of particular use at Chedabucto.

A library on the site with publications in oceanography and geology and including matters relating to oil in the sea would also have been useful and might have produced, among other things, some standardization in the use of descriptive terms there.

The ability to remove oil from the water surface as oil generally requires an equivalent ability to contain the oil and to dispose of the oil and water and other debris picked up. Such complete capability was not developed at Chedabucto although it seemed likely that the pickup machinery used there (the "slick licker") would prove effective. The system of disposal served the purpose, but would have been seriously limited in other circumstances, it seemed to me. While the requirement to dispose of large quantities did not develop the problem of containment existed at the outset and at a number of locations and under a range of current, wind and sea conditions. These factors can serve as agents of containment and, of course, if not limited, each can defeat most such attempts. It is the experience that the influence of each can be limited by the existence of sea ice, so that as containment is central to most methods of dealing with oil the relevance of ice cover needs to be understood.

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Table. Preliminary estimate of the distribution of fuel oil (Bunker C) of the tanker "Arrow" as at April 24, 1970, in imperial gallons.

In the tanker prior to the casualty	3,800,000
Removed by evaporation[1]	?
Removed by pumping[2]	1,290,000
Remaining in hull	40,000
Ashore in Chedabucto Bay	450,000
At depth within Chedabucto Bay[3]	?
At the surface within Chedabucto Bay	5,000
Into the ocean (out of the bay)	2,000,000

[1] Evaporation certainly occurred, but to unknown extent.

[2] It was reported that 36,924 barrels of oil and water were pumped from the wreck. Shortly after the stern portion sank it was reported to contain up to 7,000 tons; to what extent the estimate was revised prior to the completion of pumping was not apparent to me.

[3] A value for this fraction should be forthcoming as the data observed from ship-board becomes available.

Attachment

A selection of photographs by T. Galley on March 21. (a) Five positives of the western edge of ice in Lennox Passage which had by this date receded to a line east of Glasgow Head. (b) Two positives of Haddock Harbour. (c) Six positives of southeast Inhabitants Harbour.

VOLUME III

PART 4

REPORT ON CARGO SALVAGE OPERATION

REPORT ON CARGO SALVAGE OPERATION

SS ARROW

CHEDABUCTO BAY

FEBRUARY 12 TO APRIL 11, 1970

BY

S. A. MADSEN

The 18,151 deadweight ton tanker ARROW struck Cerberus Rock off the coast of Nova Scotia on February 4, 1970. The vessel subsequently broke in two near its mid length. The forward section remained near the rock on a general east/west heading. The stern section sank in an upright position in 90 feet of water some 1200 feet north of the rock aligned in a general northeast/southwest direction.

The cargo consisted of 108,224 barrels (42 U.S. Gallons) high viscosity industrial fuel oil and a small quantity of light fuel oil to displace the customers pipeline after the high viscosity fuel oil was discharged. The specifications of the high viscosity fuel oil were:

Manufacturers Specification Number C561	
Specific Gravity at 60°F	.964
Viscosity SSF at 122°F	280 Seconds
Pour Point	30°F
1 Barrel of Oil (42 U.S. Gallons)	35 Imperial Gallons (about)
Barrels per ton at 60°F	6.649

I arrived in Port Hawkesbury on February 12th as advisor to Imperial Oil Co. A survey of the stern section on February 14th by divers showed that oil was trapped in the cargo tanks. Rather than permit the oil to escape uncontrolled, it was felt that a procedure could be devised by combining several time tested techniques for the successful removal of the cargo without causing further pollution. The technique used in penetrating the hull was developed in the shops at Imperial Oil Co.'s Refinery at Halifax and tested at 30 feet water depth off their Pier.

I returned to New York on February 18th but was then invited by the Department of Transport to return to Port Hawkesbury on February 24th.

In a meeting on February 25th, I was invited to join a task force established by the Department of Transport to deal with pollution resulting from the ARROW. The task force was headed by Dr. McTaggart Cowan, Dr. Sheffer and Captain Martin RCN. My specific function within the task force was to assume the responsibility for the salvage operation. The salvage group comprised civilian and service personnel and equipment directly engaged in the salvage operation. The task force reserved the right to be consulted on all major decisions affecting the outcome of the salvage operation.

Deoiling Procedure and Equipment

The procedure adopted for recovering the oil trapped in the two sections of the tanker consisted of bolting a flange and 8´´ gate valve to the deck above each tank containing oil. A Cox gun was used to drive threaded studs through holes in the flange into the deck. An air driven "Hot Tap" machine capable of cutting a 7 ½´´ diameter by 3´´ thick doughnut shaped cupon from a steel plate was bolted to the 8´´ valve, a manually operated gear mechanism on the hot tap machine permitted lowering and raising the cutting tool through the open valve (see attachment).

When penetration of the deck was achieved, the cutting tool was withdrawn, the valve closed and the hot tap machine replaced with a 90° 8´´ fitting to which the cargo hose leading to the barge was connected. Due to the viscosity and gravity of the cargo, it was considered necessary to steam trace the cargo hose to increase the temperature of the cargo and to prevent cold oil from blocking the hose in the event it became necessary to discontinue pumping for any reason.

The steam trace consisted of 1 ½´´ diameter flexible metal hose installed inside the cargo hose. No attempt was made to extend the steam hose beyond the end of the cargo

hose for fear of rendering the valve useless as a means for stopping the flow of oil in the event a hose ruptured.

Several steam trace configurations were tried.

1. A complete loop.

   This configuration did succeed in the first attempt to recover oil, however, there were a number of leaks scattered along the length of the steam trace which probably assisted in lifting the oil but steam leaks near the pump put a positive pressure on the cargo hose which caused loss in pump efficiency and probably a loss in height of the column of oil in the hose which occur as the result of depth of the water and the difference in gravity of oil and water. The pressure on the deck of the wreck assuming a full tank of oil open to the sea at the bottom was 120 lbs. per square foot. On this basis, the estimated discharge rate per hose was 100 barrels per hour.

2. Steam trace terminating in a 180° open fitting.

   The purpose of the 180° fitting was to give added lift to the oil. As in the previous configuartion, pump efficiency was reduced due to steam leaks near the pump suction.

3. Steam trace terminating in an open fitting pointing toward the cargo tank.

   This configuration achieved rates in the order of 100-150 barrels per hour as compared with 25-50 barrels per hour for 1 and 2. The probable reason for the improved efficiency is that the steam hose did not leak.

   The cargo discharge temperature was about 80°F with configuration 3 and 110° -117° for 1 and 2 respectively.

Other means considered at the outset for heating the cargo included pumping heated oil in the ships tanks through a second hot tap in the ships deck. This was not tested because after further consideration it was felt that the hot and the cold oil would not mix due to the difference in gravity and viscosity.

Injecting steam through a 2″ fitting near the deck (see attachment) was tried. This procedure surprisingly failed to increase the discharge rate after apparent early success. The reason for the failure is not clear.

Six strings of 6″ and 8″ heavy duty oil discharge hose each about 120 feet long connected the fittings on the deck of the wreck to 6″ positive displacement steam driven reciprocating pumps on the barge. The pumps discharged directly into the barge's tanks through short lengths of hose and pipe inserted in openings in the deck.

The 30,000 barrel capacity non-propelled barge IRVING WHALE (see attachment) was chartered by the task force to serve as the lighter. It was moored normal to the wreck (southeast/northwest) directly above the cargo tanks to be emptied held in place by 4-7″, 1-8″ and 1-10″ circumference polypropylene ropes attached to temporary moorings laid for this purpose by the salvage tug.

The equipment put on the barge for this operation included 1-120 horsepower boiler, 1-300 horsepower boiler and associated fuel and water tanks, temporary piping, pumps and generators, two steam supply manifolds, six reciprocating cargo pumps and a quantity of rubber steam hose; a mulcher to spread peat moss in the event an oil spill occurred, a portable oil spill boom, a gasoline driven moring winch and a shack to shelter the salvage crew and boiler operations who on several occasions could not be relieved for twenty-four hours or more due to high winds and seas.

The barge was difficult to moor and unmoor due to its size, however, this was more than offset by its excellent sea keeping qualities in rough seas.

Chronology

A detailed survey of the bow and stern sections of the wreck beginning on February 26th confirmed that the stern section was essentially intact lying upright in a southwest/northeast direction. Cargo tanks seven across, eight across and nine center were clearly intact. Six starboard appeared to be intact, however, number nine wing tanks port and starboard were open to the sea. The depth above the deck was about 50 feet.

The bow section listed 10 to 15° to port. The starboard side was crushed from the cofferdam to the midships house. The crushed area extended from the bottom to within 6 to 8 feet of the deck in No. 2 starboard wing tank, tapering to within a few feet of the bottom of each end. The deck was split open from the midships house to the cofferdams on both sides of the center line of the ship. All tanks were open to the sea with the possible exception of No. one and two port tanks.

Negotiations for the barge and the Murphy Pacific Salvage Tug Curb were concluded on February 27th. Curb arrived at Port Hawkesbury on March 2nd. Hot tap operation on No. eight center tank began on March 2nd.

The four mooring legs required to hold the barge in place over the wreck were laid by Curb on March 5th and 6th. The smaller of the two boilers to supply steam to the pumps and to heat the cargo was operational on March 11th. The barge was moored in position on March 12th. Oil began flowing from the wreck to the barge at 1730 March 13th through an 8´´ hose connected on No. eight center tank.

On the night of March 15th/16th, two mooring lines parted in a southwesterly gale. Since this coincided with the arrival of the second boiler and additional hoses, the barge was towed to the dock at Mulgrave on the 16th where the additional equipment was installed. Pumping resumed on March 23rd.

Inspection of the bow section on April 7th found that further damage had occurred and that all tanks were free of oil.

After several stops due to weather and boiler failures, pumping was completed on April 11th. 36,924 barrels of oil and oil/water emulsion was recovered from tanks 6-7 and 8 starboard, 7-8 and 9 center, 7 and 8 port in the stern section. To ensure that as much oil as possible was recovered, every tank was pumped several times in a twenty-four hour period until no oil was visible in the discharge from the pumps.

Delays

The operation at the wreck site and the supply lines ashore were hampered from the outset by sub-freezing temperatures, snow, icing and a succession of low pressure systems with attending gale force winds and high seas. Other delays resulted from boiler failures, in part caused by rusty feed water, frozen feed water lines and condensate which found its way into the boiler fuel supply. Many hours of diver bottom time were expended because a detailed plan of the location of the internal structural members was not available. As a result, longitudinal beams under the deck were struck on the first four hot taps attempted. However, the divers were able to break the weld between the deck and the beams in three instances.

Recommendations

It is my opinion that a major oil spill in a coastal area constitutes a national emergency and that Government and Industry should combine forces to minimize or eliminate the effect of the spill on the local population.

The oil industry has taken steps to effectively deal with small spills and damage to property that sometimes result. Oil pollution prevention measures have been taken and continue to be stressed in crew training to ensure that both owned and chartered tankers are equipped to eliminate or to minimize the risk of these spills due to mismanagement

or equipment failure. However, neither Industry nor Government is prepared to deal effectively with massive pollution.

In the two lightering operations, in which I have been directly involved to date, the GENERAL COLOCOTRONIS and ARROW, there were substantial delays in locating and assembling equipment to undertake the lightering operation. The equipment eventually put together in this manner was at best makeshift, difficult to handle due to weight and inefficient. For these reasons, the following is recommended.

1. Establish within one governmental agency or department a national task force responsible to deal with major oil pollution incidents that exceed the ability of the ship owner or private interest to prevent substantial damage to the environment. The task force should have ready access to other government agencies or departments and the scientific, industrial and academic communities that can provide advice and assistance.
2. The task force should pre-determine on-scene commanders that are prepared to go to the scene and take charge of the government's efforts to mitigate the effects and to clean up the result of the pollution incident. The on-scene commander should have authority to take action as dictated by circumstances, including requesting assistance from other national and local government agencies including the Armed Services, to assist in transportation communication and cleanup.
3. The task force should pre-determine and publish which techniques and which locally available materials are best suited for containing, absorbing and removing oil from the water, tidal zone and beaches. This would include the pre-determination and publication of where and under what circumstances what type chemical treating agents and similar materials may be used in territorial waters.
4. The task force and the on-scene commanders should pre-determine the whereabouts and availability of tanker and petroleum experts within or outside the country that can be requested to assist in any phase of the containment and cleanup of oil spills or salvage operations. The industry experts should have ready access to cargo data and tanker design information.
5. To initiate countermeasures as quickly as possible, on-scene commanders should request tanker and petroleum industry experts to proceed immediately to the scene in every instance where pollution may result from a collision, grounding, stranding, explosion or fire on a tanker.
6. The task force should request the tanker and petroleum industry experts to attend periodic briefing sessions or meetings to keep appraised of specific problems, new developments and techniques.
7. Develop a salvage package that can be transported by air designed specifically to lighter a stricken tanker. To assure maintenance and ready access, store the packages at naval salvage depots or similar facilities in strategic locations.

In conclusion, I take this opportunity to express my most sincere thanks to the salvage team for making an idea work.

Foremost the RCN Divers who operated under most difficult conditions. Without their dedication and courage, the salvage operation would not have succeeded.

The officers and crew of the Curb, the RCN boiler tenders and the crew of the IRVING WHALE who cheerfully worked hard many consecutive hours always under uncomfortable and often hazardous conditions.

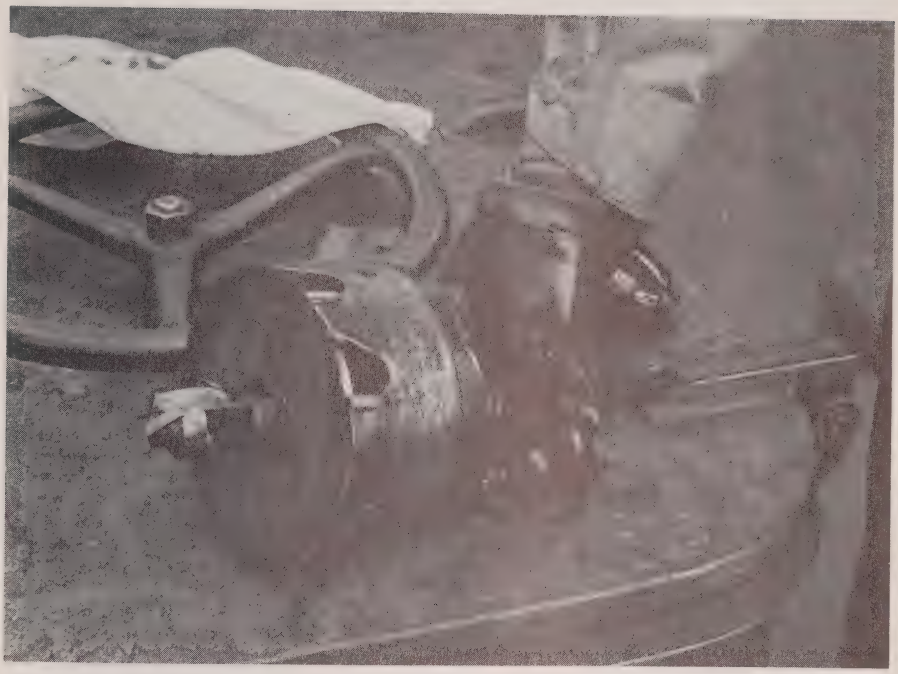
The supply group ashore who somehow managed to come up with the equipment and the spare parts required to keep the effort going.

Dr. Frank Paine and his co-workers at Halifax whose laboratory work assisted greatly in determining which procedures would most likely succeed.

Hot Tap Machine bolted to 8′′ valve which is bolted to flange.

Note: Oversized flange in part to provide stability during drilling operation, and to provide adequate clearance so that Cox gun could fire studs as near vertical as possible. Also, note 2′′ steam fitting below 8′′ valve.

Hot Tap Machine and Fittings



Hot Tap cutting head.

Note: Cupon cut from the deck of the ARROW.

IRVING WHALE moored in position

Deck of IRVING WHALE during pumping operation.

Note: Six hoses leading to wreck in lower photograph.

1. Mast of tanker *Arrow* still showing above the surface.

Le mât du pétrolier *Arrow* qui n'a pas été submergé.

2. Naval diver, covered with oil, emerges above wreck of *Arrow*.

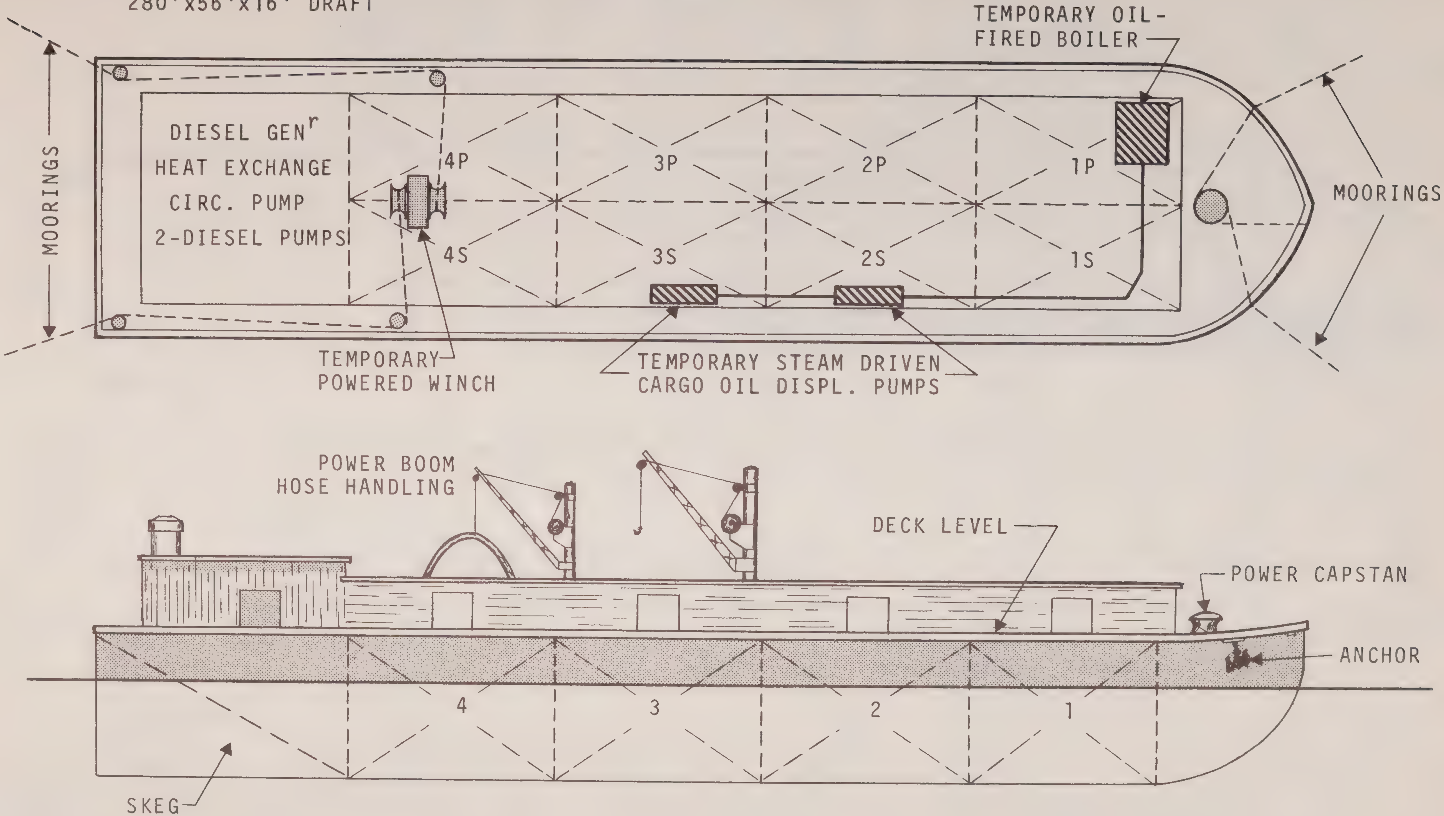
Le plongeur soit du pétrolier *Arrow* echoué complétement recouvert de mazout.

"IRVING WHALE"

TANKER BARGE

DIMENSIONS
280'x56'x16' DRAFT

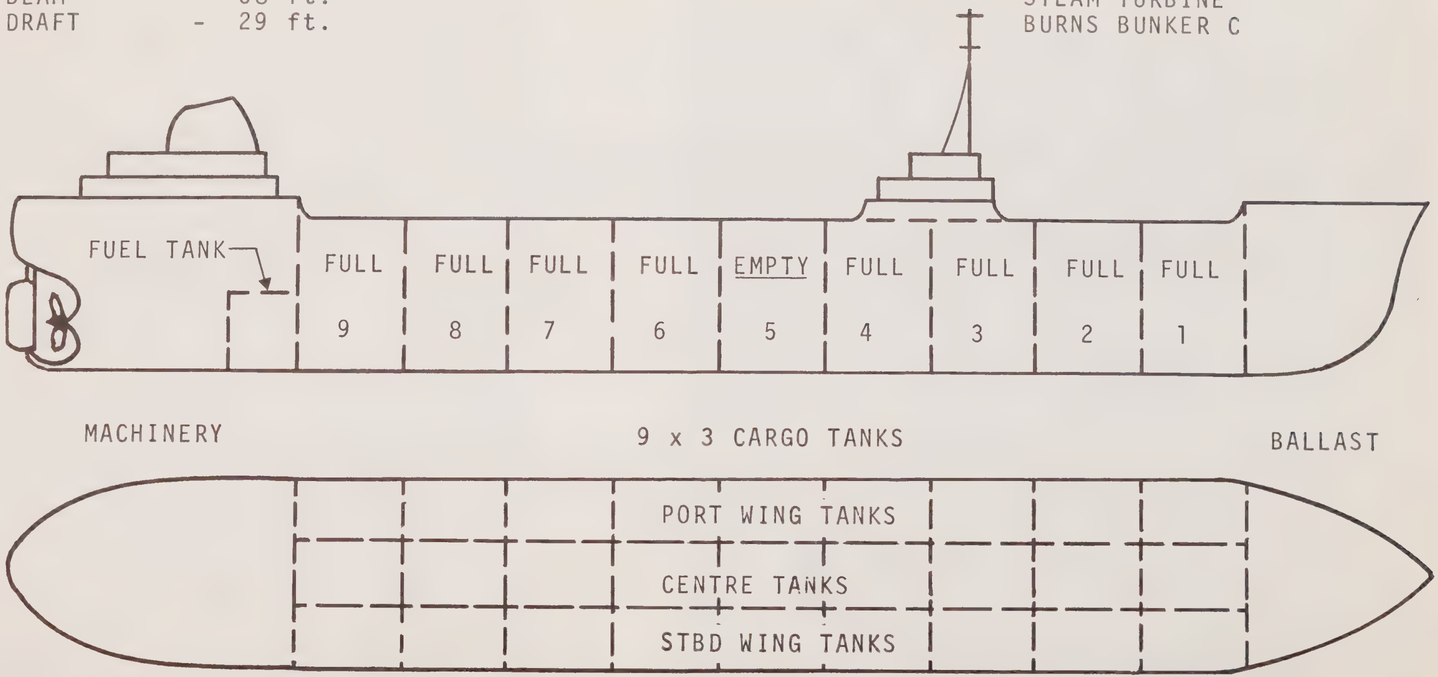
CAPACITY ABOUT 5,000 TONS
BUNKER 'C' KEPT AT ABOUT 170°F



"ARROW"

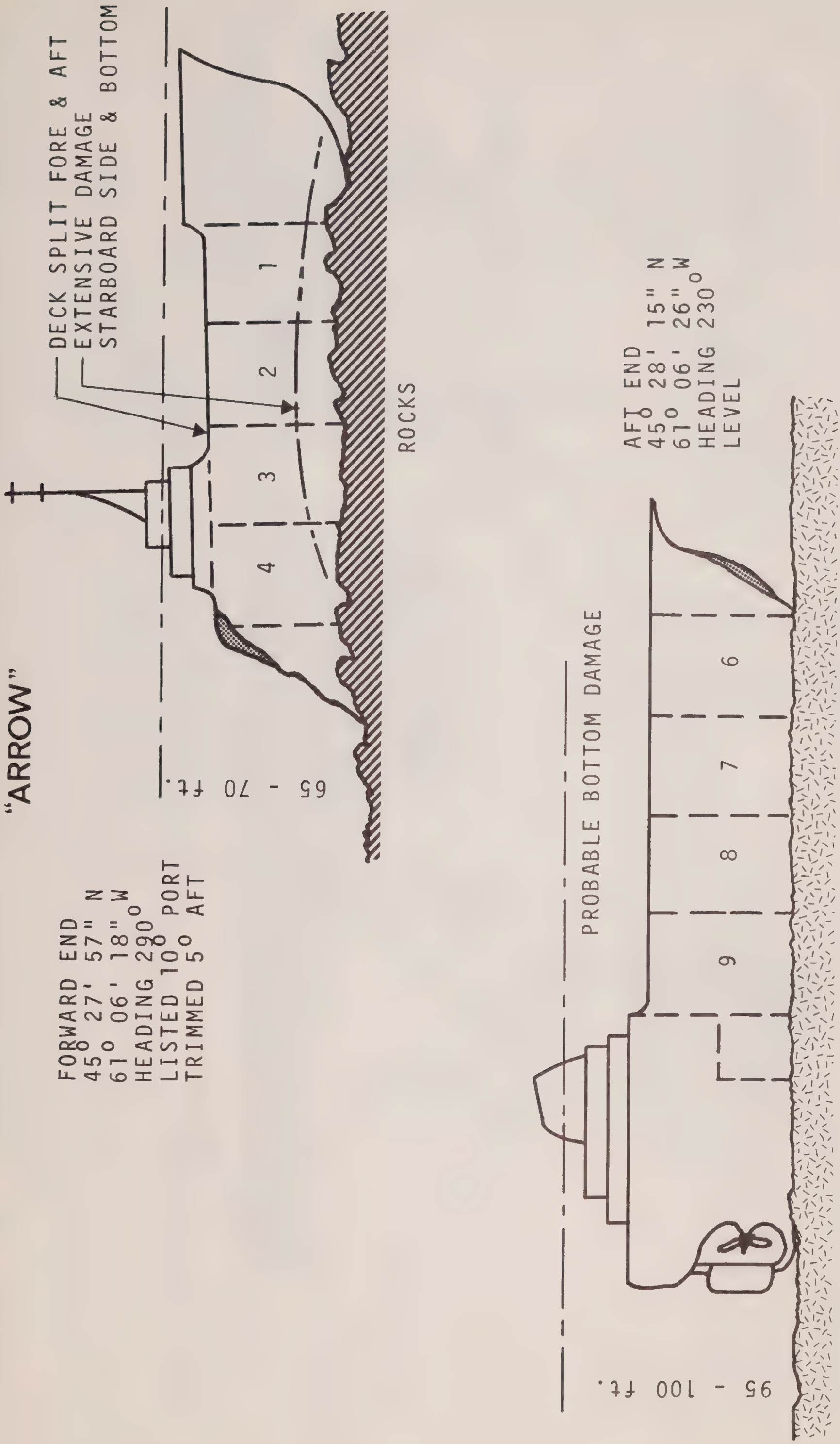
LENGTH O.A. - 551 ft.
BEAM - 68 ft.
DRAFT - 29 ft.

SINGLE SCREW
STEAM TURBINE
BURNS BUNKER C



BUNKER 'C'

APPROXIMATE TOTAL CARGO IN 8 TANKS - 16,000 TONS
APPROXIMATE CARGO EACH CENTRE TANK - 1,000 TONS
APPROXIMATE CARGO EACH WING TANK - 500 TONS

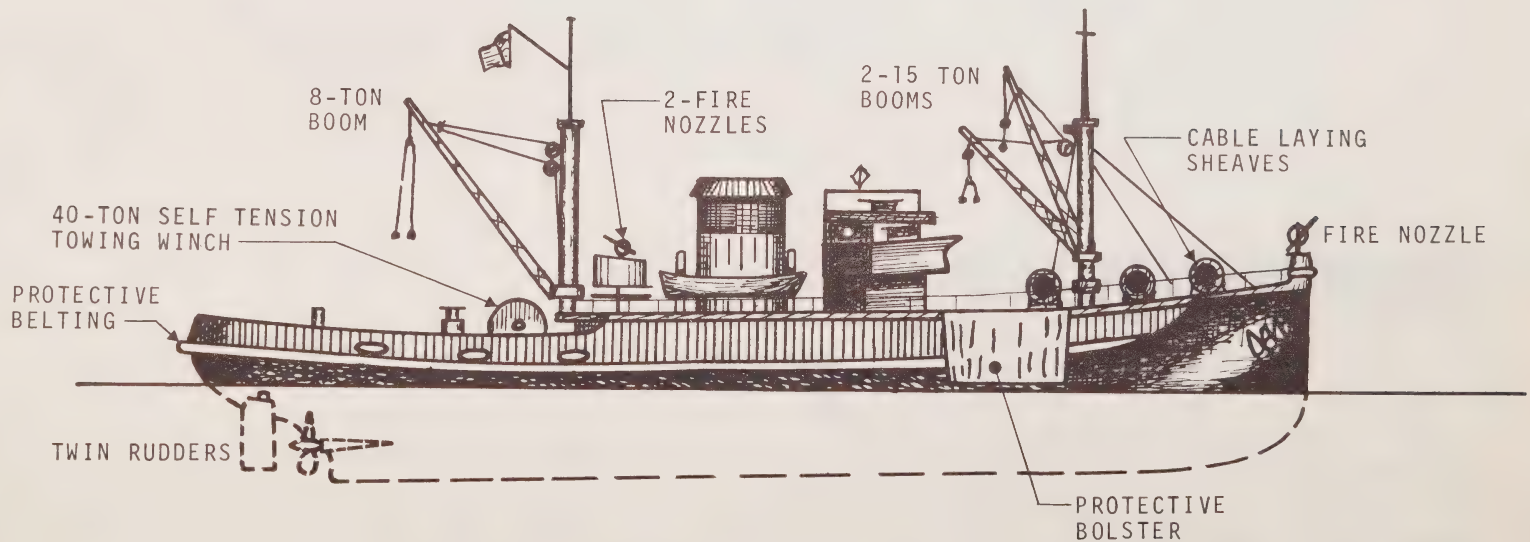

"ARROW"
FORWARD END
45° 27' 57" N
61° 06' 18" W
HEADING 290°
LISTED 10° PORT
TRIMMED 5° AFT
DECK SPLIT FORE & AFT
EXTENSIVE DAMAGE
STARBOARD SIDE & BOTTOM
65 - 70 ft.
1
2
3
4
ROCKS
AFT END
45° 28' 15" N
61° 06' 26" W
HEADING 230°
LEVEL
PROBABLE BOTTOM DAMAGE
6
7
8
9
95 - 100 ft.
GRAVEL

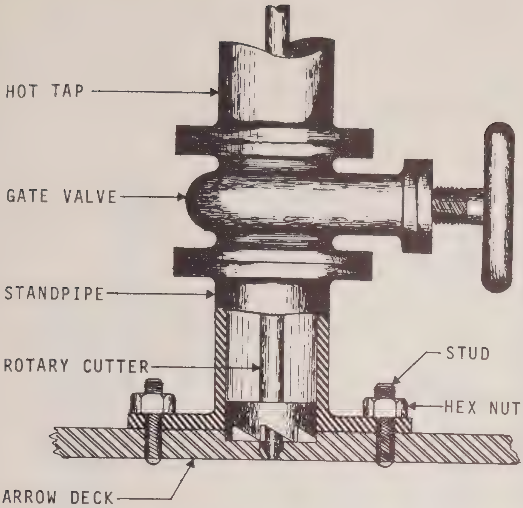
"CURB"

SALVAGE VESSEL

Approx. Dimensions 213' x 42' x 16' Draft
Twin-Screw Diesel-Electric Propulsion
About 3,000 H.P. Total at Shafts
Built for U.S. Navy Salvage Fleet

Capabilities Include Towing, Salvage, Machine Shop, Welding, Construction, Diving, Lifting, Pumping, etc.





HOT TAP METHOD

THE 'HOT TAP' METHOD IS USED FOR CONNECTING BRANCH TO TANK OR MAIN PIPELINE. SO CALLED BECAUSE IT IS USED IN REFINERIES WHEN WELDING BRANCH PIPES AND TAPPING MAIN WHILE PETROLEUM IS FLOWING.

(1) DIVER DRIVES EXPLOSIVE STUDS INTO DECK AND SECURES FLANGED STANDPIPE.

(2) DIVER BOLTS GATE VALVE TO STANDPIPE.

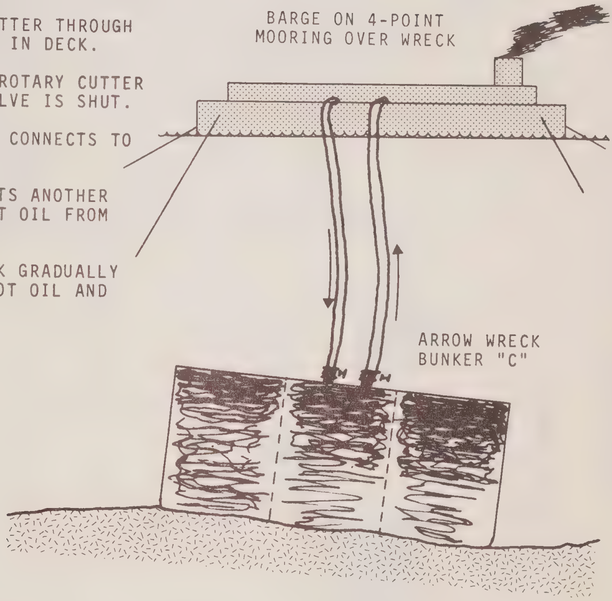
(3) DIVER OPERATES ROTARY CUTTER THROUGH OPEN VALVE AND CUTS HOLE IN DECK.

(4) WHEN HOLE IS THRU' DECK ROTARY CUTTER IS WITHDRAWN AND GATE VALVE IS SHUT.

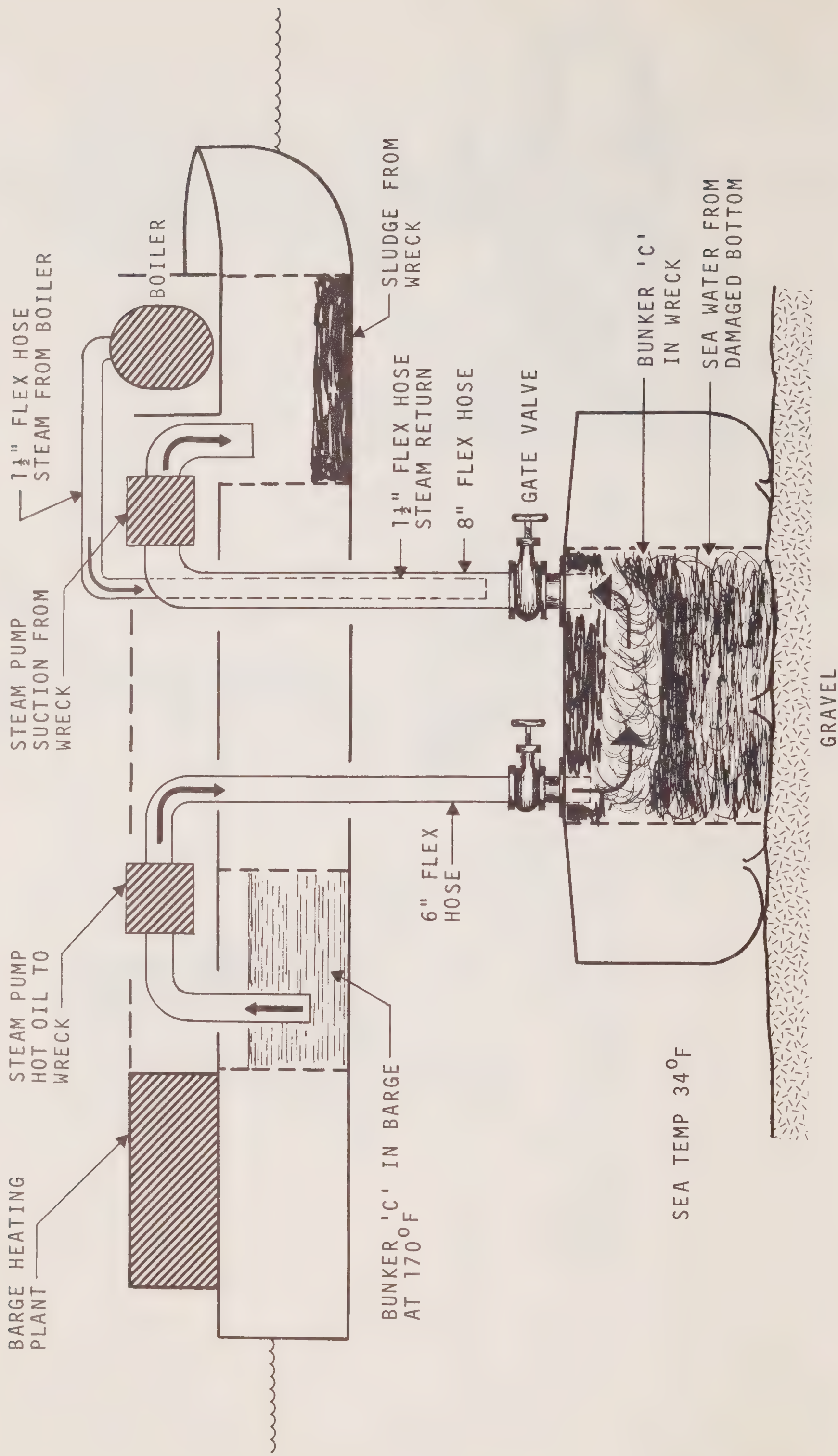
(5) FLEXIBLE HOSE FROM BARGE CONNECTS TO PUMP SUCTION.

(6) SIMILAR PROCEDURE CONNECTS ANOTHER FLEXIBLE HOSE PUMPING HOT OIL FROM BARGE INTO WRECK.

(7) TANK OF BUNKER C IN WRECK GRADUALLY WARMS UP BY CIRCULATED HOT OIL AND PUMP DISCHARGE PROCEEDS.



REMOVAL OF BUNKER "C" FROM WRECK



VOLUME III

PART 5

REPORT ON DIVING OPERATIONS

FDU (A): 3150-1

Fleet Diving Unit (Atlantic)
F.M.O.
Halifax, N.S.

12 May, 1970

Commanding Officer
Fleet Diving Unit (Atlantic)
F.M.O.
Halifax, N.S.

OPERATION OIL ("BROKEN ARROW")

Reference: A. Report of diving activities, with applicable annexes attached as follows:

ANNEX A. Details of method of tank penetration using "hot-tap" drill.

ANNEX B. Chart of Cerberus Rock area, showing positions of forward and after sections of "ARROW".

ANNEX C. Elevation of stern section.

ANNEX D. Hull plan of stern section.

1. The above report is submitted for your consideration, and onward transmission to appropriate authorities.

D.B.HOPE
Lieutenant Commander
Executive Officer

OPERATION OIL ("BROKEN ARROW")

REPORT OF DIVING ACTIVITIES

Background

The Liberian registered tanker ARROW, owned by Sunstone Marine SA Panama with a cargo of Bunker C oil bound for Canso Straits, grounded on Cerberus Rock in Chedabucto Bay in early February 1970. The ship was under charter to Imperial Oil Company.

The action of tugs resulted in the hull breaking in two across number five hold (which was for some reason empty).

The forward part of the hull, which remained firmly grounded on the rock was sufficiently ruptured as to allow most of the oil cargo it contained to excape and cause widespread pollution along the adjacent shoreline.

Atlantic Salvage Company attempted to supplement the buoyancy of the stern section and take it in tow, either for beaching in a location chosen specifically to enable the recovery of the cargo, or alternatively to a location well off-shore for sinking in deep water. The alternatives were still under consideration by the Department of Transport, which by this time had assumed control of the operation, when the decision was resolved by the stern section sinking 700 yards from the bow section still on Cerberus Rock.

Concurrent with the foregoing, research was being carried out in attempting to dispose of the considerable quantities of bunker C oil cargo which was adrift in the area and had also washed ashore or lay trapped in various bays and channels. At this time, it was hoped that disposal could be effectively achieved by burning. This method was advocated by officials of the Pittsburg-Corning Glass Company which had available quantities of small pumice-like glass beads which had proven effective in other oil spills by acting as a wick for the heavy oil. These burning trials were also actively supported by Imperial Oil Company representatives.

It was at this time that personnel from Fleet Diving Unit (Atlantic) first became involved in the operation. It was expected that the prevailing cold weather conditions (temperatures at this time were ranging from 5° -25° F) would cause ignition to be difficult. Accordingly, because the personnel of the diving unit are proficient in handling explosives, they were asked to provide assistance. Armed with an assortment of pyrotechnics and miscellaneous explosives, a small team of divers set up residence in Arichat and participated in the burning trials.

It soon became evident that no assistance was needed from the diving unit in achieving ignition. Providing the oil was first spread over with the "beads", and then primed with benzine, it easily ignited. However, the inability to achieve this initial bead coverage and benzine priming ultimately caused the burning attempts to be unsuccessful. It was during this period that diving personnel acquired a new capability as flame thrower operators. This equipment had been brought to the scene by the US Army in the event it might be the answer.

Considering that diving officers are trained as salvage officers, it was a natural consequence that an appraisal of the salvage problem should be made by the officer in charge of the diving team while in the area, even though no request for assistance in this regard had as yet been made. At the time of this appraisal, the stern section was still afloat, if somewhat precariously.

It was evident that the salvage company, which so far has been exclusively engaged in the operation, lacked both the logistic capability, and the expertise necessary to cope with the situation.

Accordingly, recommendations were passed to the Maritime Commander that in order to effectively handle the salvage aspects, it would be necessary to request adequate, competent, logistical assistance as expediently as possible from wherever available. It was also separately recommended to Department of Transport officials in Port Hawkesbury that if the stern section could be kept afloat, it should be towed to its original destination at Point Tupper for the removal of remaining cargo. However the stern section sank shortly thereafter, and was reported to be lodged in a precarious position on the bottom in danger of toppling into deeper water.

SURVEY PHASE

Consultations between Maritime Command, representatives of Standard/Imperial Oil, and the Department of Transport resulted in the Fleet Diving Unit (Atlantic) being directed by Maritime Command, to undertake a hull survey of the wreck, and to conduct diving operations as requisite to attach the necessary fittings to the tanks to enable removal of the remaining cargo.

The Department of Transport (Coast Guard) were arranging to lay mooring buoys at the wreck.

An advance survey diving team proceeded by road to Port Hawkesbury on 23 February, and subsequently boarded the CCGS SIR WILLIAM ALEXANDER on 24 February. Concurrently, trials were carried out in conjunction with Imperial Oil personnel to determine a means of attaching valves and hoses to the wreck and pump out the cargo. From the trials, a method was evolved to attach valves to the deck of the tanker with explosive bolts, and drilling a hole through the deck with a "hot tap" drill.

This method is the subject of a separate report, and is attached as Annex A.

During the period from 25 to 27 February, a diving survey was made of both the forward section of the wreck, still hard aground on Cerberus Rock, and of the after section to be surveyed, the diving team operating from CCGS SIR WILLIAM ALEXANDER which also laid the first mooring buoys in the area. The CCGS RALLY was used to conduct the diving survey of the forward section. Both surveys were carried out with a certain amount of difficulty owing to rather adverse wind and sea conditions, and air temperatures generally less than 20°F, which caused some icing of diving equipment. Diving on the wreck was also made more difficult with the heavy, adhesive black cargo oil. This was the first experience with what was to become a constant problem throughout the whole salvage task.

The survey established the following information: The after section is lying on an even keel in ninety feet of water on a gravel bottom in position latitude 45° 28′ 16″ N, longitude 61° 06′ 27″ W on an approximate heading of 230° (T). Funnel awash at high water. See Fig. 1 and 2. The visible part of the hull from the bilge keel up, appeared intact from number six tank, aft. A small rupture was detected on the starboard side at the turn of the bilge into number eight tank. The extent of rupturing below the turn of the bilge could not be determined. The ship had broken across number five tank which was consequently completely open to the sea. Subsequent examination established that number six port, and number six centre tanks were also open. At the time of the initial survey, it appeared that there was some oil leaking from the open part of number five. This later proved to be comming from within number six. There were some broken lines on the upper deck. Minor amounts of oil were running in streams from these, and from the ends of the oil lines at number five. It appeared that the majority of the oil cargo in tanks six, seven, eight, and nine was more or less intact, with whatever remained in the ship's own fuel tanks. It was later determined that tanks nine port and nine starboard were empty due to unsuccessful attempts by the salvage company to pump air into these tanks, which resulted in a loss of their cargo. Fig. 3 shows a hull plan sketch of the tanks which retained the majority of their cargo. This was later estimated to be approximately 1,300,000 gallons. Two portable low pressure air compressors were secured on deck, forward of the pump room sky light. Another compressor was lying on the bottom 50

feet from the starboard side of the hulk. Above number five starboard tank, a king-post remained intact. The corresponding post on the port side was missing.

During the examination of the fractured number five tank, it was determined that the deck thickness was ⅝ of an inch for the wing tanks, and ¾ of an inch for the centre tanks.

The forward section was found to be lying with the starboard side hard against Cerberus Rock pinnacle. The radar mast of the bridge structure is in a position 090 (T), in 100 feet from the rock awash charted position. This is in Latitude 45° 27′ 55′′ N, Longitude 60° 06′ 22′′ W. See Fig. 1. The hull is in an average depth of 50 feet, with the upper part of the bridge structure awash. The general lie of the hulk is 220° (T), and it has an estimated 20° list to starboard. The foc'sle and bridge structure were found to be more or less intact. The hull all along the starboard side was crushed and open nearly to the main deck, from forward of the bridge structure nearly to the foc'sle break. The main deck was fractured longitudinally on both sides of the cat-walk from number three tank to number one. The fracture on the port side had a maximum opening of about 2 inches. The one on the starboard side started as a hairline at tank number three and widened to a vertical displacement of approximately eight feet. There was some movement between the broken edges, and water surge caused scouring of some "gobs" of oil from within the ruptured tanks. The foremast was down, and lying diagonally across the deck and over the side. Abaft the bridge structure, the hull was completely broken up and open, through the much abraded rock beneath. The examination of the forward section resulted in the conclusion that although all tanks were ruptured, at least at the bottom, there was a probability that some oil remained trapped at the tops of tanks one, two and three port, and possibly three centre.

The details of the foregoing surveys were reported to the staff at Operation Oil headquarters in the evening of 27 February.

OIL RECOVERY PHASE

Diving tender YMT 12 departed from the Fleet Diving Unit at Dartmouth early on 27 February, and made a rough and uncomfortable passage to Canso Straits against headwinds and seas, and with considerable icing of the superstructure; finally arriving at Port Hastings and securing alongside CCGS NARWAHL at 0400 Saturday, 28 February.

Due to several minor defects incurred on passage, YMT 12 remained alongside for repairs until the afternoon of Sunday, 1 March, when passage was made to Arichat in preparation for an early start diving on the wreck next day.

On March 2, after first clearing away several stray mooring lines fouling the hulk, YMT 12 was moored in position over the stern section. A "nozzle", gate valve and "hot tap" drill was secured to number eight centre tank using the "Cox Gun" to attach the bolts for the nozzle and the first drilling commenced. A 45 gallon oil barrel was rigged to the "hot tap" drill to provide a flotation lift for ease of handling underwater. This was just one example of many instances throughout the whole operation where flotation was utilized by the divers to handle heavy gear. It was often used in preference to lowering from above due to the presence of a ground swell on the surface.

While drilling was in progress, several broken oil lines were plugged to curtail oil leakage, which, though not in quantity, made diving activities much more difficult by fouling the water, and consequently diving suits and equipment. Drilling continued until the early afternoon without achieving penetration of the ¾ inch plate, when a rising wind and sea necessitated unmooring and returning to Arichat. The problem was initially suspected, and subsequently proven, to be due to the drill being located over a longitudinal. Difficulty in avoiding these strength members was largely caused by non-availability of ship's plans. Although it was known through advice from Standard Oil consultants that the ship was of "Isherwood" construction, with frames spaced at 12 ft. 2 in. centres,

and longitudinal beams at 30 inch centres. When plans were later obtained, they were of the class only, and did not show many modifications which had apparently been incorporated in this particular vessel. Consequently, and ironically, when the plans were available, they tended to be misleading, and the most reliable method of avoiding the longitudinals was found to be by tapping the deck with a hammer.

During the 3rd and 4th of March, adverse weather prevented diving on the wreck. However these days were put to good avantage by the diving officers in meeting with and briefing the personnel of the salvage tug CURB owned by Murphy Pacific Salvage Company, which had now arrived in Port Hastings. The services of this vessel, an ex USN salvage tug (ARS) had been obtained to provide, together with a suitable container barge, the capability for pumping the bunker C oil from the wreck. Owing to limited sea-keeping capabilities of YMT 12, it had been anticipated that CURB's arrival on the scene would considerably enhance the capability for all weather diving in the Cerberus Rock area, which was in an open roadstead completely exposed to the vagaries of winter weather conditions. It was also assumed that CURB would be equipped with the diving capability she had had as a USN vessel, and would therefore relieve the cramped conditions in the 90 foot long YMT 12.

It was somewhat of a revelation to find that CURB had a total crew (civilian) of 29; had only the very minimum of diving equipment, and only two divers. She also had no medical facilities, which necessitated a medical assistant being added to the complement of YMT 12.

The requirements for mooring CURB, and subsequently the barge which will receive the oil, were discussed. These briefings and discussions resulted in the conclusions that CURB was not suitable as a diving platform for this operation, and YMT 12 was required to continue in this function, using CURB or the oil barge as a lee. The remaining king post on the wreck was an obstruction to CURB's being able to moor, and the diving team removed this by use of explosives at first opportunity.

In conjunction with the familiarization of CURB personnel, the master and mate were embarked in YMT 12 and taken to the wreck location.

Also during 4 March, a diving team carried out a survey of the foundations of Lennox passage bridges.

On March 5, diving operations were resumed on the wreck, continuing drilling on number eight centre tank, which was finally penetrated in the afternoon. This resulted in considerable elation, it being the first success in the drilling, and proved the feasibility of the procedure. Operations were hampered by ice on the deck of the tender, water temperature of 28°F, considerable fouling of divers and equipment by oil, and a rising sea and wind which reached 45 knots before operations were terminated. This day also saw CURB in the area commencing to lay a four point moor.

During the period 5-11 March, diving operations followed a general routine which usually consisted of checking the weather conditions at 0400, and if suitable, YMT 12 departing Arichat so as to arrive on the wreck at first light. On some days, weather curtailed or prevented diving.

The tender would take up a three point moor over the wreck and continue drilling operations. As previously described, during these early stages the drilling operations were somewhat time-consuming owing to the frequent occurrence of striking longitudinals. Trouble was also experienced through frequent freezing of the air vanes and hoses of the pneumatic drill. Additional delay was caused on the 7th March when the clutch shaft of the drill parted and had to be taken to Port Hawkesbury for repairs.

On 6 March, CURB completed laying the four point moor and obtained the assistance of YMT 12 to stretch the mooring legs.

On 9 March, an additional "hot tap" drill was received. This one was driven hydraulically, and had been provided by the Department of Transport. Before it could

be made to operate satisfactorily in the cold water, several modifications were progressively carried out, both experimentally, and in consultation with the manufacturer's representatives. These details are described in Annex A.

By the 11th March, tanks eight centre and eight port had been penetrated and fitted for hose attachment. At first, each tank was fitted with two nozzles and valves, intending one for steam entry, and the other for pumping oil out. However, subsequently it was found that one valve per tank was sufficient; the steam being pumped down into the tank by use of a 2 inch line within the oil hose, and also through a nipple in the side of the nozzle.

On the evening of 11 March, YMT 12 dragged the four in number, four ton, close-in moorings clear of the ARROW stern section at the request of CURB so that they would not be in the way of mooring the oil barge IRVING WHALE, which was arriving on scene 12 March.

The barge was in position over the wreck by the morning of 13 March. YMT 12 secured alongside and commenced working in conjunction with the barge crew (who were from CURB) to attach the first hose to tank eight centre. On this first hose attachment, many problems were encountered and solved. The operation consequently took most of the day. The lessons learned were put to good use with subsequent hoses. The following general procedure was evolved.

A 90 degree elbow was attached to the gate valve to allow the bight of the hose to lie on the deck of the tanker and provide scope for the rise and fall of the barge in the swell, and tide range. A jackstay was attached between the barge and the elbow; the end of the hose was secured to the jackstay with a strop and shackle, and thereby lowered down the jackstay to the elbow. In some cases, where it was necessary to clear the sag of the hose over the cat-walk or other obstructions, it was supported in more than one place to the jackstay. A flotation barrel was used on occasion to aid in manhandling the hose.

On 14th March, considerable swell made conditions unsuitable for diving. However, the end of the hose was inadvertently lost from the barge, so YMT 12 proceeded alongside the WHALE with some difficulty and carried out diving to recover the lost end; under very marginal conditions.

Diving operations were resumed on 15 March, and continued during daylight hours until the afternoon of the 16th, when deteriorating weather forced a halt in activities, and necessitated the IRVING WHALE being removed from the moor and taken to Mulgrave for shelter. On 15th, the clutch shaft of the pneumatic drill broke once again, which caused some delay.

During this period, the feasibility of attaching the nozzles to the side of the tank tops and drilling horizontally into them as illustrated in Annex A was investigated. This idea was subsequently discarded for the following reasons:

The tank tops were constructed of only quarter inch plate, and might easily rupture and cause an oil spill; COX GUN ammunition of the correct load for plate thickness was not available; and, nozzles with curved flanges could not be manufactured locally with sufficient accuracy.

During the night of 16 March, and until the afternoon of the 17th, a strong southwesterly gale made the berth at Arichat jetty completely untenable for YMT 12. It became necessary to anchor in the lee of Jerseyman Island. The inadequacy of the diving tender's anchor and cable made necessary constant vigilance throughout the night.

On 18 March, the diving tender moved one of the four ton moorings at the wreck to the anchorage in the lee of Jerseyman Island to provide more adequate holding in future gales.

Diving operations were resumed on 19 March and continued daily until 21 March, the following tanks were penetrated and were fitted with valves and elbows ready for hose attachments; eight starboard, nine centre; seven centre, and seven starboard.

Orders were received to remove the funnel of the ARROW to ensure that it would not be in the way of the IRVING WHALE when she returned to position. This was undertaken with regret, as it served as a very good point of reference for the wreck's position, and would make an excellent cofferdam should any attempt at refloating the hulk be considered in the future. This removal commenced 19 March, using a series of explosive cutting charges, and was completed on 20 March. As each of many sections was severed, it was towed clear with the diving tender. The necessity to keep the charges as small as possible to minimize the risk of damage to the tanks made the removal a time-consuming process. The result gave a clearance of approximately 12 ft. over the superstructure, and left a hole with a mean diameter of 20 feet. Some structural damage to the deck immediately abaft the funnel location, and to the engine room skylights, also resulted.

On the evening of 21 March, the barge's moorings were cleared of stray lines and made ready for her return, anticipated 23 March. Additional pumping capabilities were being installed while in Mulgrave.

CURB returned with IRVING WHALE on the morning of the 23rd and secured in the moor. Diving was resumed to recover the hose to eight centre tank and to rig additional hoses. Deteriorating weather allowed only the hose to eight centre to be hooked up that day. Unfortunately, this hose was once again lost overnight and required recovery in the morning.

During the 24th and 25th of March, hoses were attached to the following tanks and pumping commenced: nine centre, eight port and eight starboard.

Considerable difficulty was experienced trying to locate suitable positions on the ship's bunker tanks for the drill, owing to the clutter of piping in this area, and the overhang of the deck above.

On the afternoon of 25 March, after fitting a nozzle and valve in what seemed the only available location on the centre bunker tank, it was found that the drill would not quite fit under the deck-head above. A small 4 ½ lb. cutting charge was placed to cut a small wedge in the deck-head. This most regrettably jarred open the tank-top of the centre bunker, and the bunker fuel within escaped in an oil spill. Large quantities of peat moss were dispersed over the escaping oil, which at this time did not appear to be in great quantity.

Radio difficulties prevented an immediate report of the spill. YMT 12 recovered gear and proceeded to Arichat where a report was passed by telephone.

At 1830 on 25th, the diving tender was ordered to proceed to sea with Captain Madsen of Imperial Oil and Captain Stuart of the Department of Transport aboard to act as OTC for the oil spill contingency plan forces afloat. Underway by 1930, YMT 12 remained at this task overnight, determining and reporting the location and quantity of the oil spill. By 0600 on 26 March, it was evident that the oil was well dispersed and moving offshore. All marine units were accordingly secured.

Due to the requirement to rest personnel and repair equipment, diving for 26 March was cancelled.

Adverse weather prevented resuming operations until 28 March. From 28 March to 2 April, the following was accomplished: Tanks seven port and bunker starboard were penetrated and fitted for hose connections. Tanks eight centre and eight port were pumped clear of oil. The hose from eight port was shifted to seven port. Problems were being encountered in getting oil from eight starboard, so the hose was moved to seven starboard. It was determined that eight starboard required another penetration. This was achieved 2 April. The wing bunker tanks were found to be empty. During the afternoon of 2nd April, with a gale forecast, IRVING WHALE slipped all hoses with the assistance of divers, and was removed from the mooring and taken to Mulgrave by CURB.

In the evening of 2 April, YMT 12 departed Arichat and proceeded to Port Hastings,

just ahead of a rising gale, to obtain technical assistance in repairing several mechanical and electrical defects from HMCS CAPE SCOTT which had now joined the task force as a logistics support and accommodation vessel. On arrival, no sheltered berth could be obtained, and the tender was forced to secure alongside the exposed wall at the entrance to the lock, ahead of CAPE SCOTT. Heavy seas caused superficial damage to the port rubbing strake, and the tender experienced a very uncomfortable night. CAPE SCOTT technicians boarded on arrival and worked throughout the night on YMT 12 defects – CAPE SCOTT also assisted in rigging extra berthing lines to ease pressure of diving tender on dockside.

After completing repairs and loading stores, YMT 12 returned to Arichat in the evening of 4 April.

Weather conditions prevented the WHALE from returning to the wreck until 1330 on 6 April. Diving was then commenced to recover hoses. By the end of the day, hoses to the following tanks had been brought aboard WHALE and pumping resumed: seven port, seven centre, seven starboard, eight centre, and nine centre.

On 7 April, tank nine centre was pumped out and the hose removed and attached to eight starboard. Tank six starboard was penetrated and fitted for pumping; the last one to be drilled.

On this day also a detailed re-survey of the forward section of the tanker was carried out to definitely establish the presence or absence of oil cargo remaining. This examination disclosed that the two or three heavy gales since the initial brief survey two months previously had caused considerable disintegration of the hull; with the result that it was firmly established that no oil in quantity remained. At the time of the first survey, the port side of the hull was more or less intact, which made it possible that some oil might be trapped in the upper parts of one, two and three port tanks. The hull was now extensively wracked and ripped open. At the same time, settling had taken place onto the rock beneath. All tanks were open to the sea. It was possible to enter through the many rents in the ship's side and see right through the hull to the opposite side of the ship. There was a vestige of oil remaining trapped in those tank tops which were still in situ.

Between 9 April and 11 April, diving and pumping operations were able to continue without any major interruptions. Tanks were progressively pumped free of oil, and hoses were shifted accordingly. As each tank was emptied, the elbow and gate valve were removed and a blanking plate fitted in lieu. By the evening of 10 April, all tanks were empty and blanked off except six, seven and eight starboard.

By the afternoon of 11 April tanks six and seven starboard were empty and capped. Water was being pumped from eight starboard and it was considered to be empty. However the hose was found to be leaking at the joints on removal. In fact, the joints separated during recovery, and the tank appeared to have some oil remaining. This was reported to the salvage master aboard the barge. Information was received that the tank was not considered to contain any large quantity of oil and instructions were given to cap it off. This completed the pumping operations. YMT 12 proceeded to Arichat, and the barge IRVING WHALE was unmoored and towed to Mulgrave by CURB.

The diving team remained at Arichat during 12th and 13th of April, generally cleaning the diving tender and equipment. On the afternoon of Sunday, 12th, a diving display was staged for the benefit of the people of Arichat. When the crew of the two army helicopters who were operating in the area learned of the plans, they supplemented the demonstration with a flying display; which resulted in a well balanced combined operation. This was publicized on the previous evening in the local branch of the Canadian Legion, and on the next morning by announcements in the churches of the area. The result was an overwhelming turn-out of the populace, which created a considerable traffic jam, and a dense crowd on the jetty. The public were permitted aboard the tender in controlled numbers. A special feature for the children was provided in an opportunity to "fish for pop", with divers attaching the "catches".

On 14 April, at 1700 the diving team from Fleet Diving Unit (Atlantic) and YMT 12 were detached from Operation Oil, or “Broken Arrow”. The tender made an uneventful passage overnight in calm seas to Halifax Harbour and secured at the Diving Unit in Dartmouth at 0730 on 15 April.

This completed the oil recovery phase of the operation.

COMMENTS, CONCLUSIONS AND RECOMMENDATIONS

For the purpose of gaining experience in a unique operation under somewhat difficult conditions, and as a general test of capability, the whole operation was of great value to the divers. In this connection, it is considered that the opportunity to work in close association with Captain Sven Madsen of Esso International, with his extensive knowledge, sense of humour, and considerable diplomacy was indeed a privilege!

The diving conditions were not too unusual; Canadian naval divers more often than not, are required to work in cold water and cold weather, frequently in exposed locations. However, the ubiquitous black oil, and the duration of the task, made the operation one of a kind.

Of all the lessons learned, the most valuable one is considered to be that there is an adequate potential capability within Canadian resources to cope with practically any salvage operation within reason. However, Operation Oil has exposed the almost complete lack of national organization or preparedness for such a task. The Naval Diving Branch has not been permitted to create a salvage capability, this being considered the sacrosanct prerogative of the civilian salvage companies. However, it would appear that such companies that may be in existence lack the technical and financial scope and the expertise necessary to undertake a major salvage operation such as the recovery of oil from ARROW. When this lack of capability results in such a far-reaching consequence as the oil pollution of Chedabucto Bay, the catering to these private interests becomes decidedly unrealistic.

The necessary expertise, if not the necessary equipment, can be found in Fleet Diving Units, particularly with regard to underwater operations. There is also undoubtedly a considerable wealth of knowledge available in the naval constructor, engineering, and boatswain branches. However, the almost complete lack of readily available basic hardware required for a major undertaking renders all of this expertise relatively impotent.

"Basic hardware" is intended to mean such fundamentals as pumps, ground tackle, anchors, chain and wire cables, buoys, air compressors, flotation equipment, and last but not least, an adequate salvage vessel.

Operation Oil has proven that practically all of the logistic requirements of a full scale operation can *ultimately* be consolidated on the scene from a multitude of sources within Canada. The majority of the necessary equipment is to be found within the combined resources of the navy and Coast Guard. However, the degree of success which is possible to achieve in such salvage operations is in direct proportion to the rapidity of efficient and *adequate* reaction.

It follows therefore, that what is basically required is a stockpiling and consolidation of equipment in locations readily available to a task force, together with a contingency plan which will provide the necessary organization and importantly, its rapid, utilization.

It is strongly recommended that Fleet Diving Units be a major source of information concerning the details of the required equipment.

It is also strongly contended that Fleet Diving Units must have continuing access to much of the basic hardware which would normally be retained in the previously described depots. This for the purpose of familiarization and training.

In summary, even though the sinking of the tanker ARROW and resultant oil pollution was a major disaster, the subsequent salvage of the remaining cargo provided a unique and valuable experience for diving personnel. It has, particularly with the benefit of hindsight, taught many lessons, and has emphasized a major shortcoming in preparedness for such a disaster. Not to take full advantage of these lessons, by adequately providing for future emergencies, would be at least, regrettable.

Annex A to
FDU (A): 3150-1
dated 12 May 70

METHOD OF DRILLING OF TANKS AND FITTING NECESSARY VALVES FOR HOSE CONNECTION

1. A "nozzle" was especially manufactured with a wide flange at the bottom. This was to enable a vertical positioning of the "COX" gun while firing the threaded studs through the holes of the flange and into the deck.

2. A gate valve was mounted above the nozzle, and the tapping machine attached onto the gate valve. With the gate valve open, the boring bar and cutter was lowered by crank through the gate valve and nozzle, and into contact with the deck. It was then put in gear, and boring commenced.

3. The pilot drill and cutter combination removed a "do-nut" shaped "coupon" from the deck; and retained it on the pilot drill by means of either spring loaded ball bearings, or in some cases an inset ratchet arrangement.

4. After penetration, the boring bar and cutter, with the do-nut retained, were cranked back through the nozzle and gate valve, whereupon the valve was closed, facilitating removal of the tapping machine.

5. Subsequent to the tapping machine removal, a 90 degree elbow was mounted in its place, and the hose attached in turn to the elbow.

6. This procedure is illustrated in Figure 4 of this annex. Both a pneumatic, and a hydraulically operated tapping machine were adapted and successfully used underwater. In the pneumatic machine, the oil in the gear case was changed from SAE 90 to SAE 30 to compensate for the 30°F water temperature. In the case of the hydraulic machine, in addition to the same oil change, several additional modifications were carried out before satisfactory operation was achieved, these were:

   a. the hydraulic fluid was diluted with diesel oil by one third;

   b. some check valves were removed from the hydraulic lines, to provide easier flow;

   c. the gear ration was lowered; and,

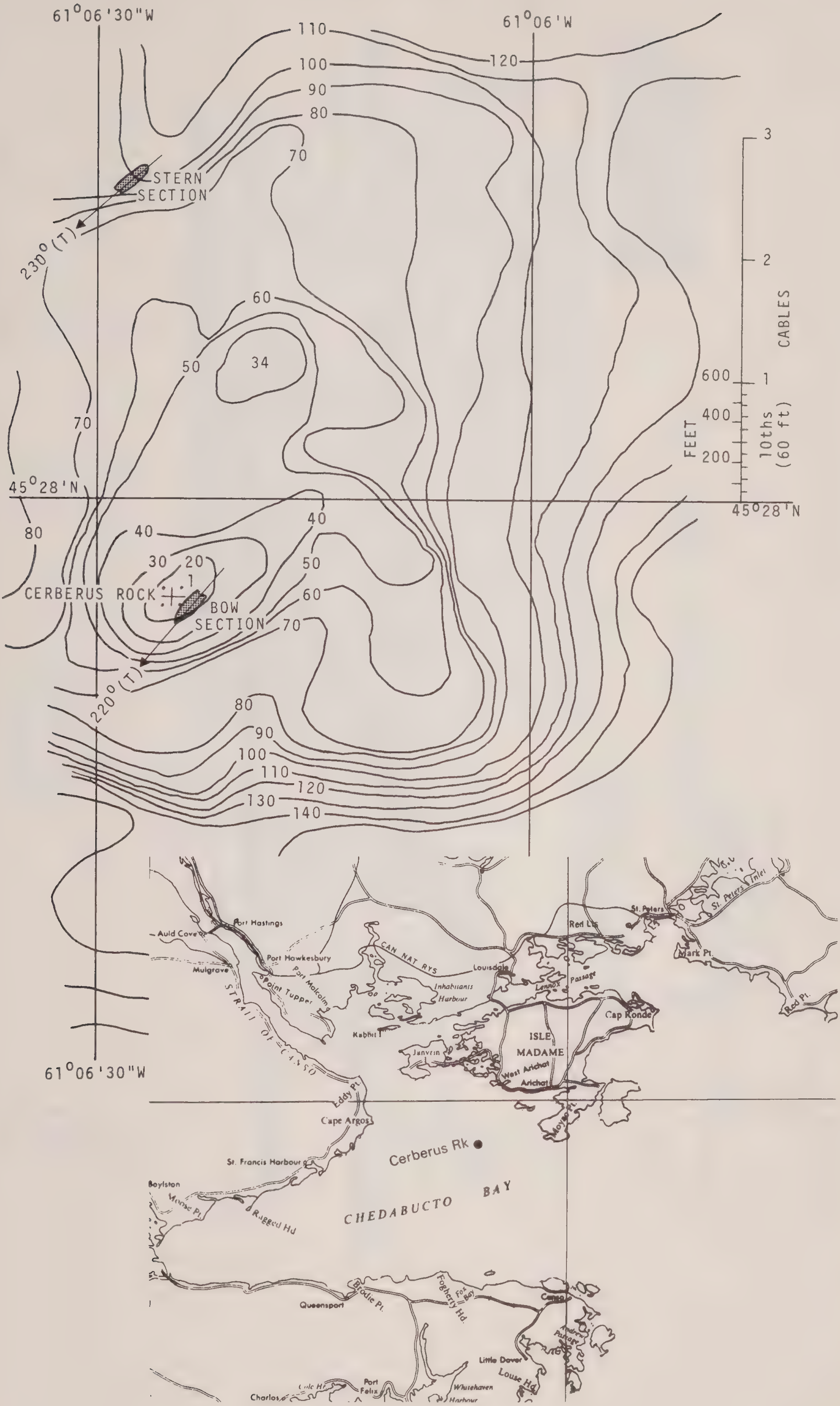
   d. the number of teeth in the cutter was reduced by one half by cutting off every other one, to reduce the load. This was rationalized by the fact that the trapping machine is basically intended for penetrations of the sides of curved pipes, in which case not all teeth would be bearing at once.

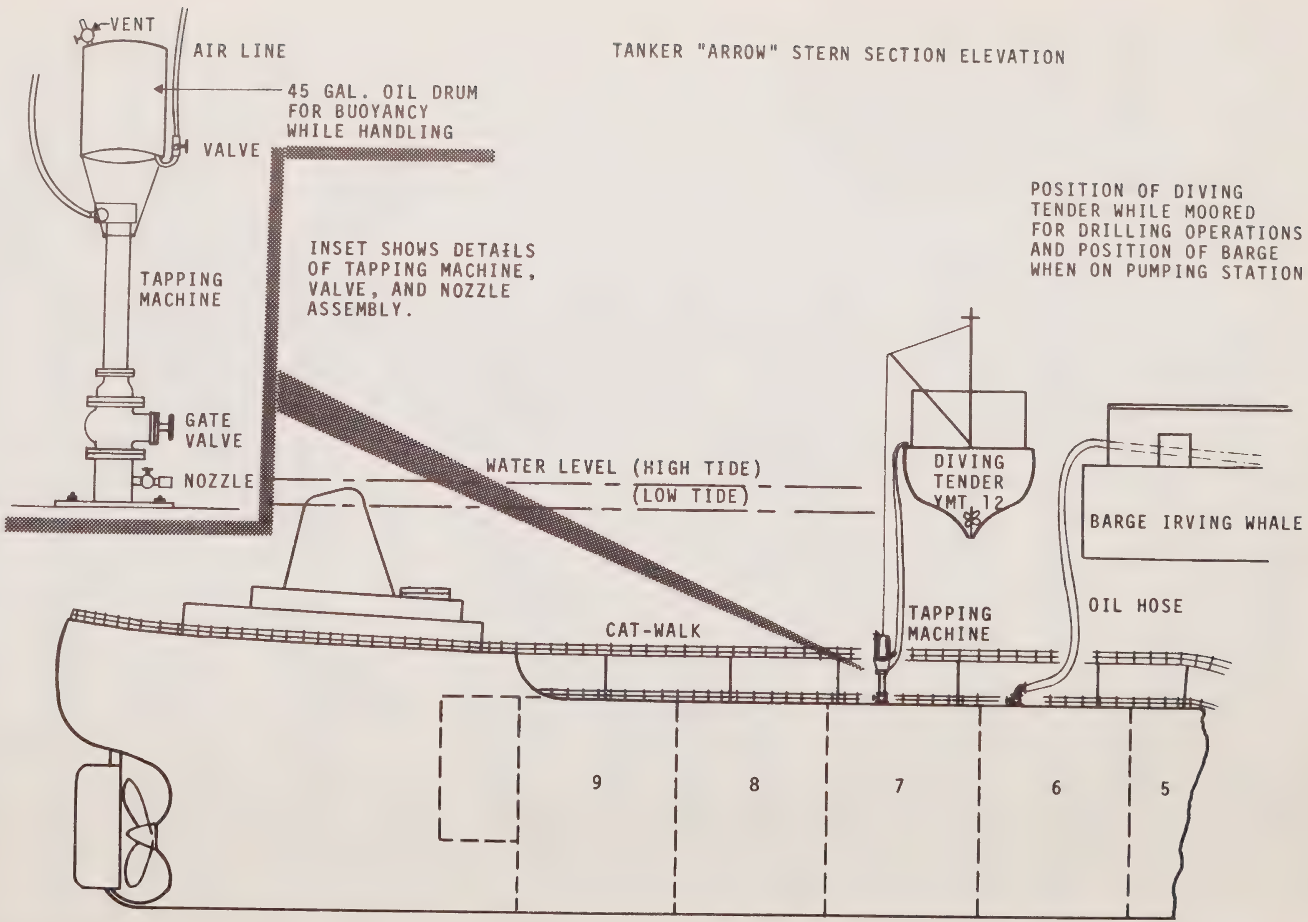
7. During the use of these machines underwater, (for which they were not designed) the oil in the gear box became emulsified with water. After about two weeks operation, this oil was flushed out and replaced. No damage to the gears, or the machine generally, appeared to result from this unique application, apart from some slight external corrosion.

8. It was found that the whole assembly, (tapping machine, gate valve, and nozzle) could be readily handled and moved into position underwater when lightened with an air filled 45 gallon oil drum.

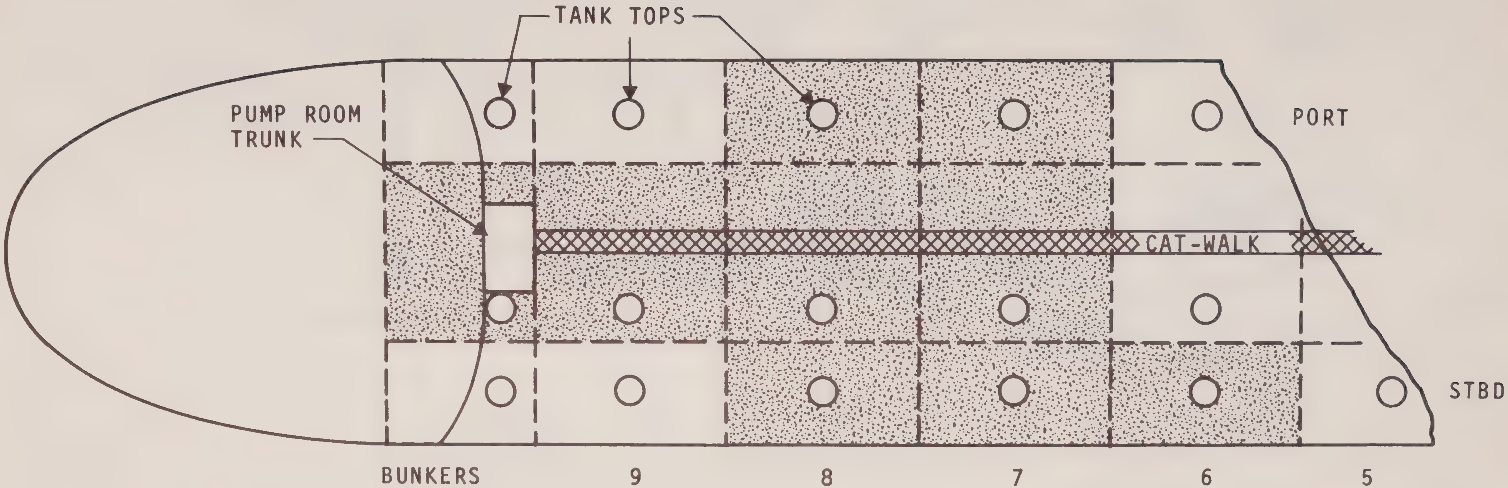
9. Drilling into the sides of the tank tops as a means of achieving more complete oil removal was considered and partially attempted, but was not pursued, due to difficulties in achieving a tight fit on the curved surface, and the danger of rupturing the tank top from the deck, through wrenching of the hose. The tank top being constructed of only quarter inch plate. This proposed method is illustrated in Figure 5.

"CERBERUS ROCK AREA"

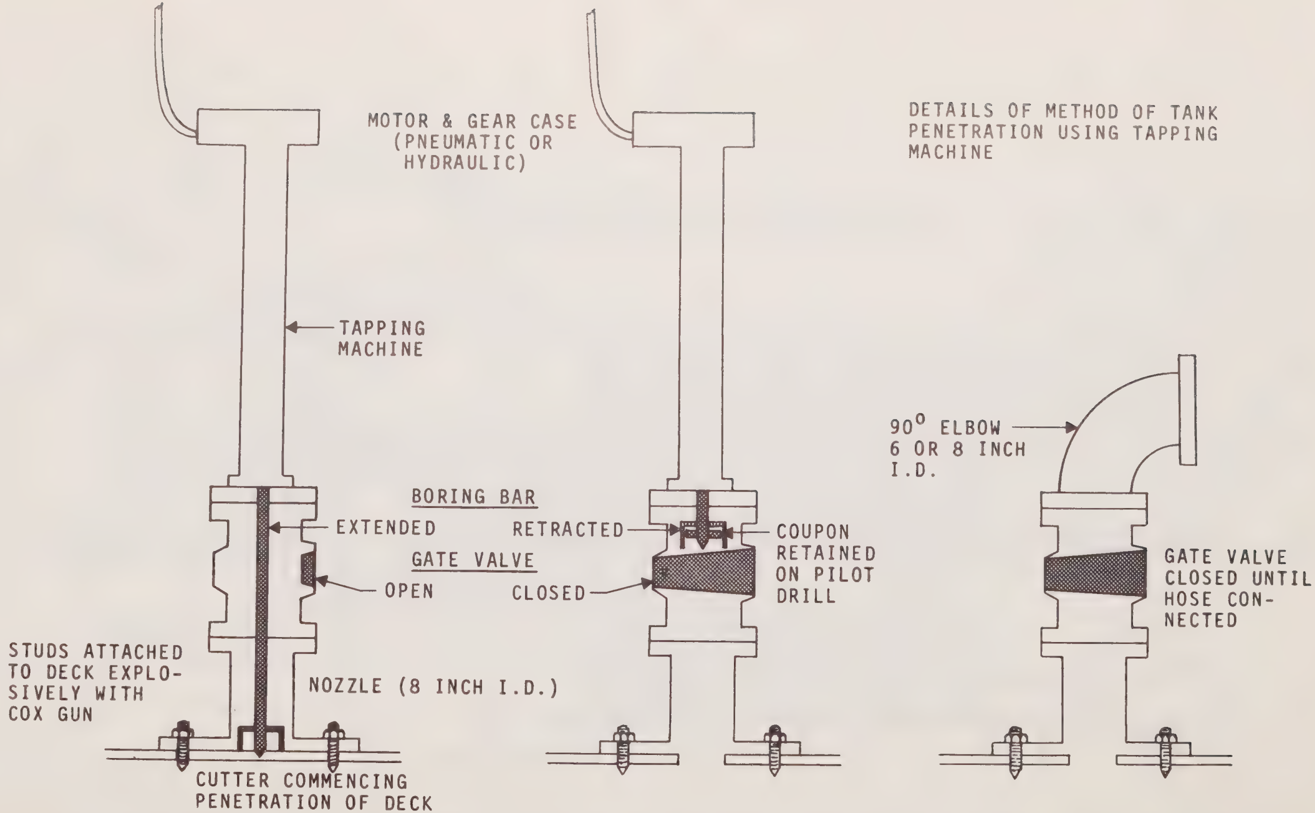



TANKER "ARROW" STERN SECTION ELEVATION
VENT
AIR LINE
45 GAL. OIL DRUM
FOR BUOYANCY
WHILE HANDLING
VALVE
TAPPING
MACHINE
GATE
VALVE
NOZZLE
INSET SHOWS DETAILS
OF TAPPING MACHINE,
VALVE, AND NOZZLE
ASSEMBLY.
WATER LEVEL (HIGH TIDE)
(LOW TIDE)
POSITION OF DIVING
TENDER WHILE MOORED
FOR DRILLING OPERATIONS,
AND POSITION OF BARGE
WHEN ON PUMPING STATION.
DIVING
TENDER
YMT 12
BARGE IRVING WHALE
TAPPING
MACHINE
OIL HOSE
CAT-WALK
9
8
7
6
5

"ARROW"
STERN SECTION



SHADED AREAS INDICATE INTACT TANKS
CONTAINING BUNKER 'C' CARGO



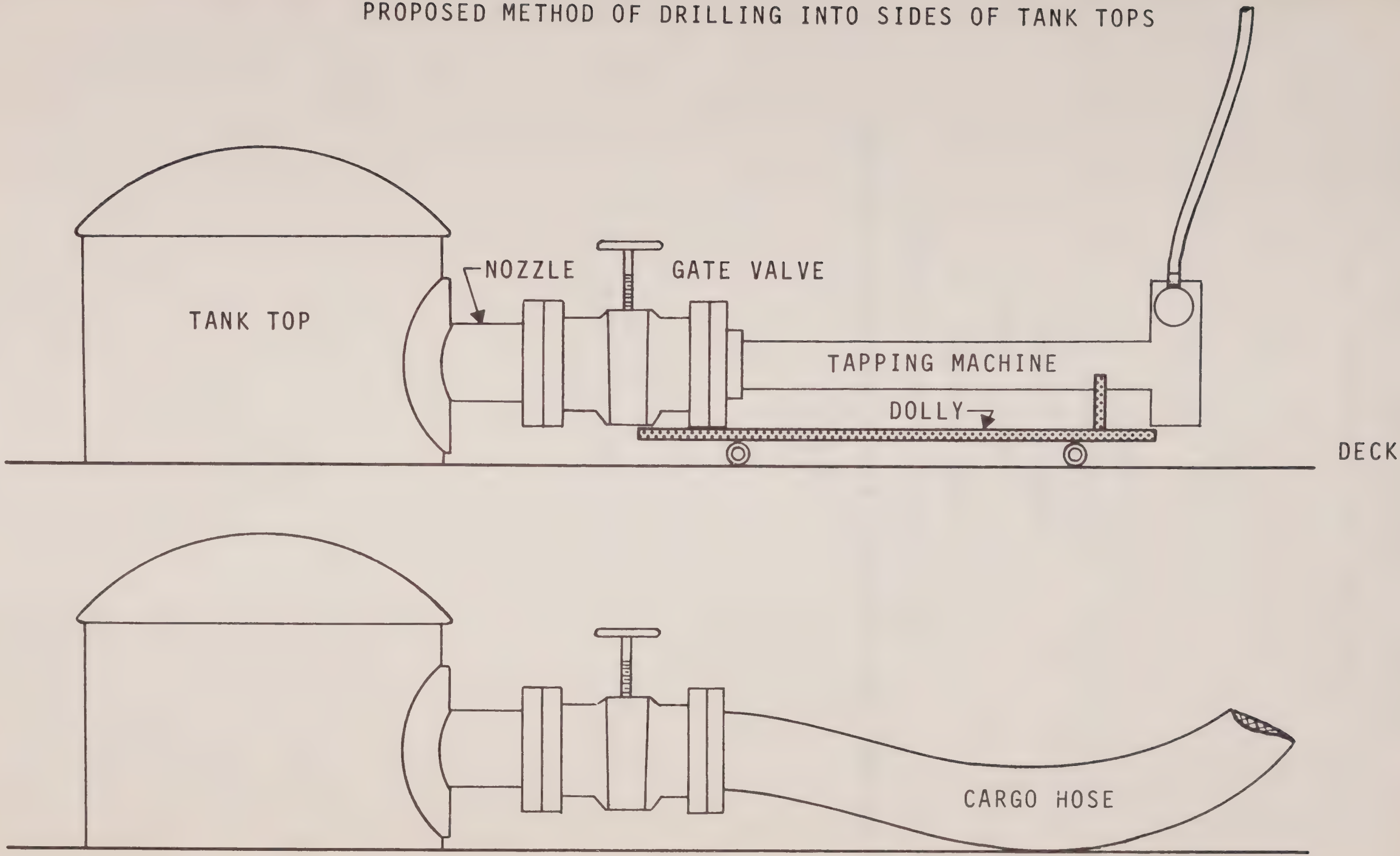
DETAILS OF METHOD OF TANK PENETRATION USING TAPPING MACHINE

(1) TAPPING MACHINE, GATE VALVE, AND NOZZLE ASSEMBLED & MOUNTED ON TANKER DECK, AND CUTTING COMMENCED.

(2) PENETRATION OF DECK COMPLETED, BORING BAR & CUTTER RETRACTED WITH COUPON RETAINED ON PILOT DRILL. GATE VALVE CLOSED.

(3) TAPPING MACHINE REMOVED. 90° ELBOW SECURED TO GATE VALVE, READY FOR HOSE CONNECTION.

PROPOSED METHOD OF DRILLING INTO SIDES OF TANK TOPS



VOLUME III

PART 6

REPORT ON SEINE NET FOR CONTAINING BUNKER C OIL SLICKS

REPORT ON SEINE NET FOR CONTAINING BUNKER C OIL SLICKS – CHEDABUCTO BAY, NOVA SCOTIA

by

H. Douglas Johnston
Regional Representative
Industrial Development Branch
Fisheries Service
Department of Fisheries & Forestry of Canada

for

The Task Force
Project Oil – Chedabucto Bay
March 26, 1970

INTRODUCTION

As the result of the grounding of the Liberian oil tanker M.V. Arrow on Cerberus Rock, Chedabucto Bay, Nova Scotia, February 4th, 1970 a number of bunker C oil slicks have been floating on the surface which pollutes fishing gear, beaches, boats, etc. On March 4th the Task Force, appointed to deal with this problem, requested that the Fisheries Service of Canada investigate the possibility of using a net to contain such slicks.

This project was assigned to the Industrial Development Branch of the Fisheries Service on March 4th. On March 20th a net was turned over to Captain M. Martin of the Task Force following two days of successful trials and training of personnel to handle the net.

OBJECTIVE

To construct a seine capable of surrounding and containing a bunker C oil slick.

PROCEDURE

The following steps were necessary to accomplish the objective:

(1) Interview herring purse seine skippers who were fishing in Chedabucto Bay and who had encountered oil slicks in the course of fishing.

(2) Witness experiments at the Bedford Institute which were conducted in a 15 foot diameter tank using simulated currents, sea water temperature, bunker C oil slicks and fish netting.

(3) Construct a net and carry out actual trials in Chedabucto Bay.

(4) Engage and demonstrate to experienced fishermen in the area the method of handling the net.

DESIGN

The two main parameters for designing the net were:

(i) Use material readily available and

(ii) Make the net so it could be handled by conventional Cape Island lobster boats which also are readily available.

Prior to designing the net a shut-off net was investigated on Grand Manan Island, New Brunswick. It was found to be much too light i.e. the twine, head and foot ropes and floats. Following this it was decided to construct a net 180 fathom x 5 fathom (see attached drawing). It is made in three sections, each a third of the overall length. The middle section, known as the bunt is made up of 210/21 x ¾ inch mesh nylon twine while the wings are made up of 210/12 x ¾ inch nylon twine. A three foot strip of 210/12 x ¾ inch nylon twine is attached to the head rope and wrapped up over the floats and fastened to the main net. This gives double netting approximately 3 – 4 inches above the water surface, the heighth of the floats.

The ¾′′ mesh was chosen as this was the smallest size mesh commercially available. The opinion of purse seine skippers, who encountered oil, was that their net (1 1/8′′ mesh) was suitable for this purpose and tests at the Bedford Institute indicated 1′′ mesh netting provided a fairly good barrier for bunker C oil slicks.

The depth was selected at thirty feet because:

(a) the tests at Bedford showed that bunker C when caught in a current submersed quite readily,

(b) the nylon twine netting comes in a standard width of approximately 30 feet,

(c) the foot rope on the net rises approximately 5 feet when being towed and

(d) it was reasonably assumed that the net would set well at this depth.

The length was selected in accordance with the capability of two Cape Island boats towing the net.

TRIALS

The first trial was held in clean water (free of oil slicks) northeast of Green Island, Chedabucto Bay. The boats selected were as follows:

THE "ELDON AND GRAHAM"

TYPE	–	Cape Island
LENGTH	–	37 Feet
BEAM	–	12 Feet
H. P.	–	225 (Chrysler Marine)
PROPELLER	–	3 Bladed 18/22
SKIPPER	–	George Keating, Rocky Bay, N.S.
CREW	–	Gus Keating, Petit De Grat, N.S.
	–	Benedict David, Petit De Grat, N.S.
	–	Felix Landry, Petit De Grat, N.S.

THE "BUD AND JACK"

TYPE	–	Cape Island
LENGTH	–	39 Feet
BEAM	–	13 Feet
H. P.	–	165 (G. M.)
PROPELLER	–	4 Blade 20/17
SKIPPER	–	Raymond Goyetche, Arichat, N.S.
CREW	–	Hirman Joshua
	–	Newman Landry

It took fifteen minutes to set the net and within fifteen minutes the net was towing in a U-formation with the tide and in the direction of a light wind. Following this both boats turned away from each other, opening the net and finally reversing the direction of towing. This manouver was accomplished in twenty minutes. The net was then taken on board, each boat hauling in on their respective towing end of the net. Once the net was out of the water and both boats broadside the net was completely landed on one boat, in this case the Eldon and Graham. The net was folded in the boat with floats to the stern and foot rope forward. It took thirty minutes to haul the net out of the water and loaded on one boat. Four men are required on each boat to bring the net abroad.

The net set well and the Cape Island boats were capable of manouvering the net

sufficiently for containment purposes. They were able to tow the net in U-formation at a very slow rate of speed against the tide and a light wind. The floats extended approximately 3 – 4 inches above water and it was quite evident that the twine which was wrapped over the floats in the bunt section would have to extend on both wings the full length of the net. The netting over the floats made an excellent barrier above the surface of the water.

Following the addition of twine on both wings a second trial was conducted and the following persons were in attendance besides the regular crew:

Captain M. Martin – Task Force

Mr. Des. Dobson – Bedford Institute

Public Relations Officer – Task Force

Fishery Officer A. Terrio – Arichat Fisheries Service Office

Mr. William Pope – Fisheries Service

Mr. H. D. Johnston – Fisheries Service

The results of this trial were satisfactory and it was the considered opinion of Captain Martin, and others who had seen floating oil for which the net was designed, that the net could successfully achieve the objective of containing and towing bunker C oil slicks.

Captain Martin then met with Mr. Gus Keating and made arrangements for him to look after the net and in the case of an emergency to co-ordinate the use of this net.

With the net trials successfully completed and a trained crew prepared to operate the net, this project was considered finished.

Acknowledgements

(1) Mr. Wm. Pope tech-advisor from the Canadian Fisheries Service I.D.B., Newfoundland who designed, supervised the construction of and carried out actual trials and modifications to the net.

(2) Mr. Gerald Brothers technical advisor from the Canadian Fisheries Service, I.D.B., Newfoundland, who assisted in the design and construction of the net.

(3) The Staff at the Bedford Institute who carried out experiments on the containing of bunker C oil slicks using various mesh sizes of fish netting.

(4) Skippers of purse seiners contacted regarding this matter for their valued opinion.

(5) Mr. Jack Creeper Fisheries Service representative on the Task Force for expediating the development trials.

(6) The entire fisheries service staff at Arichat and specifically Fishery Officer Adrian (Hogan) Arsenault for arranging charters, crew, net loft for modifying the net and in general assisting with development trials.

(7) The Task Force on Project Oil for their interest and confidence.

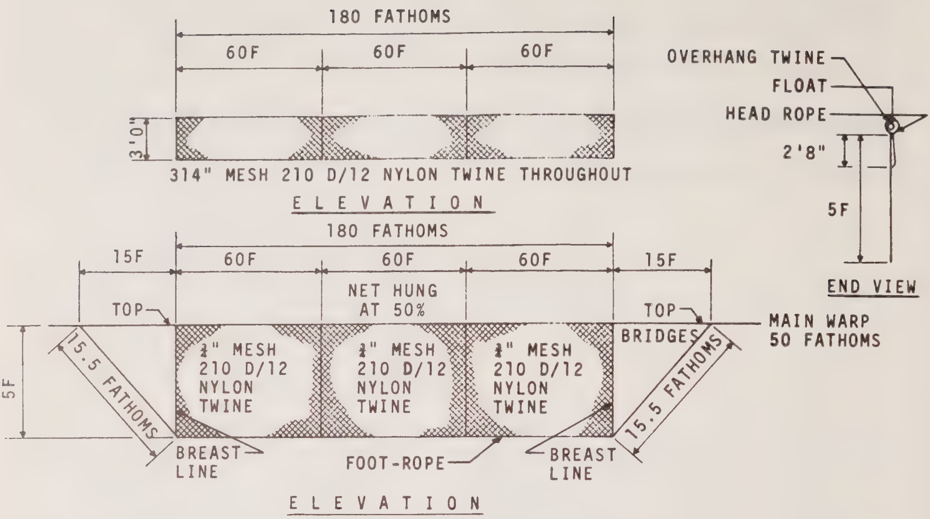
(8) Mr. John Mortin of the Grimsby Group for his assistance in expediating materials.

Department of Fisheries, Canada

Drawing No. M-A-1066, March 25, 1970

SEINE NET FOR CONTAINING

BUNKER "C" OIL SLICKS



1. HEAD-ROPE CONSISTS OF ½" SPUN COVERED CORK LINE WITH 12 MESHES HUNG TO EACH 4½" OF ROPE.
2. FLOAT-ROPE CONSISTS OF ½" POLYPROPYLENE WITH FLOATS ATTACHED @ 12" CENTERS. [ON BUNT, BUNT PURSE-SEINE FLOATS. (S-2 SEINE FLOATS)] [ON WINGS, BODY PURSE-SEINE FLOATS. (S-1 SEINE FLOATS)]
3. FOOT-ROPE CONSISTS OF 5/8" POLYESTER WITH 12 MESHES HUNG TO EACH 4½" OF ROPE.
4. LEAD-ROPE CONSISTS OF 5/8" POLYPROPYLENE WITH 4 OZ. LEADS ATTACHED AT 12" CENTERS.
5. BREAST-LINE CONSISTS OF ½" SPUN COVERED CORK LINE WITH 8 MESHES HUNG TO EACH 4½" OF ROPE.
6. BRIDLES CONSIST OF 7/8" BRAIDED POLYPROPYLENE ROPE.
7. ALL WEBBING SHALL BE HUNG WITH #30 BRAIDED NYLON TWINE.
8. LASTAGES SHALL BE PUT IN WITH 210 D/15 NYLON TWINE.
9. OVERHANG TWINE LACED ONE MESH BELOW HEADLINE YORKIN AND WRAPPED OVER FLOATS EXTENDS 2' - 0" DOWN THE WEB, AND AGAIN LACED TO THE WEB. CARE SHOULD BE TAKEN TO HAVE EACH BAR OF EACH MESH OF THE OVERHANG TWINE MEET EACH BAR OF EACH MESH OF THE SEINE TWINE HALF WAY.
10. MAIN WARP CONSISTS OF 1" BRAIDED POLYPROPYLENE.
11. ATTACH SWIVELS BETWEEN MAIN WARPS AND BRIDLES.

VOLUME III

PART 7

REPORT ON DESIGN AND CONSTRUCTION OF SEAWATER FILTRATION PLANT FOR BOOTH FISHERIES

REPORT ON DESIGN AND CONSTRUCTION OF SEAWATER FILTRATION PLANT FOR BOOTH FISHERIES, PETIT DE GRAT, N.S.

MARCH 1970

Prepared for:

The Operation Oil Task Force

by

CANADIAN PLANT AND PROCESS ENGINEERING LIMITED
Consulting Engineers
Halifax Canada

March 25, 1970

REPORT ON DESIGN AND CONSTRUCTION OF SEAWATER FILTRATION PLANT FOR BOOTH FISHERIES, PETIT DE GRAT, N.S.

INTRODUCTION

On March 6, 1970 a preliminary "Report on investigation of seawater supplies to various fish processing plants affected by the Arrow oil spill", was presented to the Task Force outlining preliminary laboratory results of experiments using polyurethane as a filtration medium.

Canadian Plant and Process Engineering Limited was authorized to proceed with further laboratory testing and also with the design and construction of filtration systems for the Booth Fisheries plant at Petit de Grat and the Acadian Fisheries (Canso) Limited plant at Canso, Nova Scotia, on the understanding that if alternate sources of supply presented themselves, that work on the project would be stopped. The completion date was estimated as March 31, 1970.

On Sunday, March 8, Dr. McTaggart-Cowan, in a telephone conversation advised Mr. John Jay, President, Canadian Plant and Process Engineering Limited, that an alternate source of supply had been obtained for the Acadia Fisheries plant at Canso and that our efforts should be concentrated on the plant of Booth Fisheries at Petit de Grat.

LABORATORY TESTING

With the cooperation of the Bedford Institute, additional laboratory apparatus was procured and set up under the direction of Dr. Gary Dillon, P.Eng. of the Chemistry Department, Nova Scotia Technical College, retained by Canadian Plant for this project and Mr. E. A. Ross, Civil Engineer of our staff. A complete report of the laboratory experiments, together with photographs of the various materials used and the apparatus, follows.

The preliminary laboratory results reported in our report dated March 5, 1970 indicated approximately 90 percent removal. We are now pleased to report that various configurations of polyurethane will give 100 percent removal and the design of the filter medium has been changed accordingly.

It is our intention to use a combination of rigid polyurethane chips which are readily available locally as a by-product of the wallboard insulation business, as a preliminary roughing filter followed by a flexible open cell polyurethane disc of a Type F14 manufactured by Monsanto in Toronto. This configuration was chosen based on the laboratory results and the low cost of this material.

FILTRATION PLANT DESIGN AND CONSTRUCTION

Design work on the filtration plant commenced on Saturday, March 7th. and had been completed and approved by the Nova Scotia Water Resources Commission by Wednesday March 11th. Materials were procured commencing March 11th. with delivery to the site commencing on Tuesday, March 17th. The construction and assembly of the plant with a design capacity of 600 gpm was completed by March 25th. and the system readied for operation.

CONCLUSIONS

We are optimistic that the plant as installed by Booth Fisheries will provide a satisfactory solution to the problem faced by the plant if the seawater intake becomes contaminated with oil.

Additional research work should be done in order that this technique can be further refined. The applications are many, with refinery wastes and ships bilge water wastes being two applications which quickly come to mind. The National Research Council and the Bedford Institute have both become interested in this experiment and perhaps they would see fit to continue this research work to a more difinite conclusion. We would be pleased to cooperate with either of these groups if we could make a useful contribution.

Our involvement in this phase of the project would now appear to be finished. The filtration plant is in operation a week earlier than anticipated. The budget figure approved on March 6th. has not been exceeded and the subsequent laboratory investigations have improved the performance from the earlier anticipated 90 percent to 100 percent efficiency.

Respectfully submitted,

Canadian Plant and Process Engineering Limited.

JOHN JAY, P.Eng.,
President.

PILOT PLANT INVESTIGATION ON THE REMOVAL OF BUNKER C FUEL OIL FROM SEA WATER

Prepared for

Canadian Plant and Process Engineering Limited Consulting Engineers

Dr. G. B. Dillon, P.Eng.

Halifax, Nova Scotia

March 20, 1970

Introduction

As a result of a request from Mr. J. Jay, President Canadian Plant and Process Engineering, Limited, received on March 10, 1970, a pilot plant study was undertaken to investigate the removal of Bunker C from sea water.

The purpose of these pilot plant studies is three fold:

(1) to determine an effective filter medium for the efficient removal of Bunker C from sea water.

(2) to determine design data for scale up to a plant size filter.

(3) to develop an analytical technique for the determination of Bunker C in sea water.

With the assistance of the Bedford Institute of Oceanography a pilot plant model was completed on March 19, 1970 and housed at B.I.O. (See Figure 1. Appendix 1) Analytical techniques were developed with the assistance of the National Research Council. (See Appendix 11).

2. Pilot Plant (General)

In the construction of the pilot plant the following design criteria were considered:

(1) capability of handling approximately 10 gal/min ft2 of filter (Based on an anticipated plant intake flow rate of 600 gal/min.).

(2) capability of gravity feeding the filter.

(3) simplicity of design for ease of operation and maintenance.

(4) allowance for both continuous and batch operation.

Previous experimental studies carried by Canadian Plant and Process Engineering Ltd. (A report on the removal of Bunker C fuel oil from sea water March 5, 1970), indicated that the use of rigid and flexible polyurethane chips presented an effective method of Bunker C removal. Thus in the construction of the pilot plant filter a design was adopted whereby both chipped polyurethane as well as continuous polyurethane pods could be investigated as a filter medium. A detailed description of the pilot plant is included in Appendix 1.

3. Pilot Plant Investigation

A series of eight (8) runs was carried out which allowed for investigation of various filter medium arrangements as well as methods of operation. Three types of polyurethane were investigated.

(1) Rigid polyurethane chips (approximately 1″ – dia.).

(2) Flexible polyurethane chips (approximately 2″ cubes).

(3) Flexible polyurethane discs (20″ dia – 4″ thick).

Both continuous and batch operations were undertaken with combinations of the above three types of filter medium. The following table outlines these combinations and method of operation.

Table 1

Run No.	Method of Feed	Filter of Medium
1 2 3 4	Batch	48″ of flexible disc (12 discs – 4″ thick).
5	Continuous	26″ of filter medium 1-4″ disc at bottom of filter. 22″ of rigid polyurethane chips. 50 cc of correxit added to feed makeup.
6	Continuous	48″ of filter medium 1-4″ disc at bottom 44″ of rigid polyurethane chip.
7	Continuous	48″ of filter medium 1-4″ disc at bottom 44″ of flexible polyurethane chip.
8	Continuous	4″ of filter medium 1-4″ disc at bottom

4. Experimental Techniques:

Batch operation: 220 gals of sea water were added to the feed storage tank along with a sufficient quality of Bunker C to give a representative concentration level of Bunker C in sea water at the intake to the filter. Samples at the intake and outlet of the filter were withdrawn at regular time intervals and analyzed for Bunker C. Outlet water from the filter was sewered.

Continuous operation: A similar procedure was adopted as in the batch operation except that outlet water from the filter was returned to the feed tank. This enabled a longer run time. Sampling was carried out as above.

Results (Pilot Plant): The following table summarizes the results for the eight runs.

Table 2

Run No.	Time Mins	Flow Rate gal/min	Flow Rate gal/min ft^2	Plant # # Flow Rate gal/min	Fluid Temp	Fluid # head in.	inlet	ppm oil outlet
1	0	18.4	8.4	660	37			
	2					4		No Detectable oil in inlet samples (See discussion)
	4					5		
	6					6		
	8					6		
	10					6		
	0	18.4	8.4	660	37			
	2					3	3.8	0
2	4					4	22	0
	6					4	11.2 21.2	0
	8					4	2.5	0
	10					4	2.3	0
	0	18.0	8.3	650	38			
	2					4	6.4	0
3	4					5	21.8	0
	6					6	7.3 3.8	0
	8					6	2.7	0
	10					6	2.4	0
	0	19.0	8.8	690	37			
	2					4	2.3	0
	4					5	2.5	0
4	6					5	2.0 1/6	0
	8					5	1.9	0
	10					5	1.6	0
	0	18.3	8.4	660	37			
	1						> 550	16.1

Run No.	Time Mins	Flow Rate gal/min	Flow Rate gal/min ft^2	Plant ## Flow Rate gal/min	Fluid Temp	Fluid # head in.		inlet	ppm oil outlet
5	5					See		> 550	13.7
	10					Note		> 550	13.4
	15					(1)		> 550	17.1
	20							> 550	17.1
	0	18.2	8.3	655	37				
	5							6.4	0
	10					See		2.2	0
6	15					Note	3.2	3.3	0
	25					(1)		1.7	0
	35							3.6	0
	45							1.7	0
	0	18.3	8.4	600	37				
	10							7.4	0
7	15					See		4.9	0
	25					Note		8.1	0
	35					(1)	6.0	5.6	0
	45							3.7	0
	0	18.3	8.4	660	37				
	15							5.4	0
8	25					6	7.9	10.6	0
	35							4.2	0
	45							10.3	0

Note (1) No visible head above chips

\#   Fluid Head measured with reference to top disc in filter
\#\# Based on equivalent loading with 10 ft - dia. filter

5. Discussion

The operation of the pilot plant filter utilizing various filter medium combinations and gravity feeding indicated that in all cases except run # 5 removal of oil was carried out. In the case of run # 5 a dispersal agent "Correxit" was added to the feed tank. This caused a breakup of the Bunker C into small particles which appeared in the filter outlet. However it should be observed (Table 2) that a very high inlet concentration of Bunker C was present (> 558 ppm). At this high concentration level the filter was able to remove 97 percent of the inlet oil.

Run # 1 is included in the table of results. No detectable oil was found in Run # 1 since an insufficient quantity of oil was added to the feed tank. However this run does indicate the head attained prior to any oil deposition on the filter medium. It can be seen that even after three further runs (approximately 600 gals of feed) no detectable increase in head occurred even though the top filter disc was heavily coated with oil. (See photograph Appendix III). Upon removal of the top disc no detectable oil was observed on the second disc indicating a high removal rate per disc.

In the use of both polyurethane chips and disc it was observed that a large amount of the oil was deposited on the chips with no detectable oil appearing in the outlet.

Conclusion and Recommendations:

(1) Polyurethane was found to be an effective filter medium for Bunker C removal of sea water.

(2) Continuous flexible polyurethane was found to be the most effective form of filter medium.

(3) Complete removal of Bunker C was observed in all cases except in the presence of dispersal agent (with correxit 97% removal). The loading rate was equivalent to actual plant conditions 10 gals/min-ft^2.

(4) Gravity feed system possible.

(5) A combination of 3-4 feet of rigid polyurethane chips with 4-8 inches of continuous flexible polyurethane on the bottom of the filter appears to be the most effective combination of filter medium.

(6) No detectable smell of Bunker C was observed in those runs which indicated complete removal.

(7) The feasibility of "in plant" foaming of the continuous layer be investigated. It is also suggested that the bagging of any chipped material to be used as filter medium, be investigated. This would allow for quick and easy removal of spent filter medium.

APPENDIX I

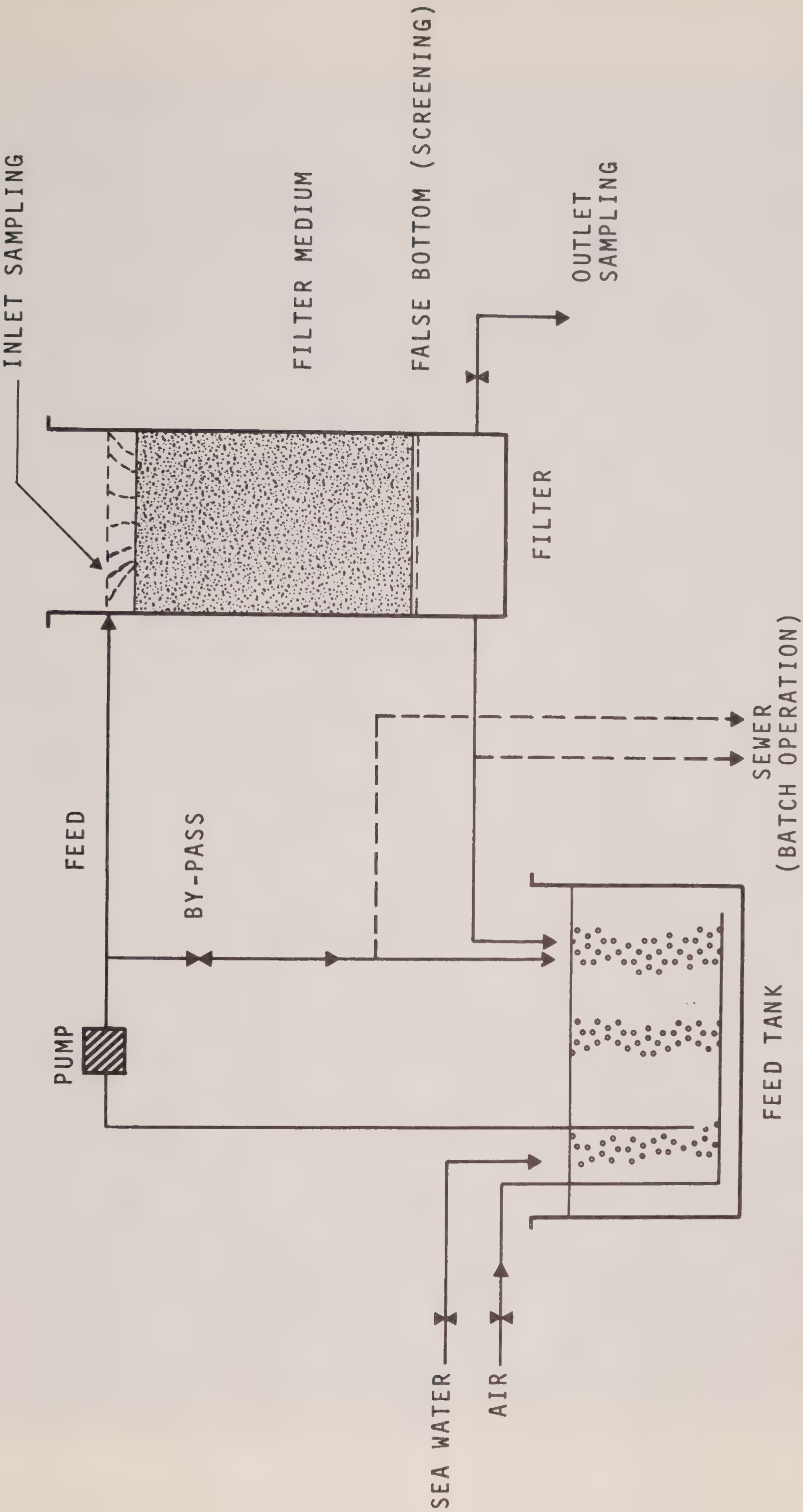
APPENDIX I

Pilot Plant Apparatus:

The pilot plant filter was located at the Bedford Institute of Oceanography and consisted of a 6 foot - 20 inch diameter filter fitted with a false screen bottom and a flanged top. Mild steel was the material of construction. A fibre glass tank of 275 gal capacity was used to store sea water drawn from the Bedford Basin. Sea water was withdrawn from the tank and fed to the filter by means of centrifugal pump. A by pass on the pressure side of the pump provided for the return of feed stock to the tank or sewer. Filtrate was removed from the bottom of the filter by means of a 4 inch plastic line fed either to sewer (Batch operation) or to the feed tank (Continuous operation).

A 1 ¾″ sample line fitted with a valva was provided at the base of the filter. Mixing of the feed tank was maintained by blowing air through a perforated ring at the bottom of the feed tank.

See Figures 1 and 2 for details of the apparatus.



INLET SAMPLING
FILTER MEDIUM
FALSE BOTTOM (SCREENING)
OUTLET SAMPLING
FILTER
FEED
BY-PASS
SEWER
(BATCH OPERATION)
PUMP
FEED TANK
SEA WATER
AIR

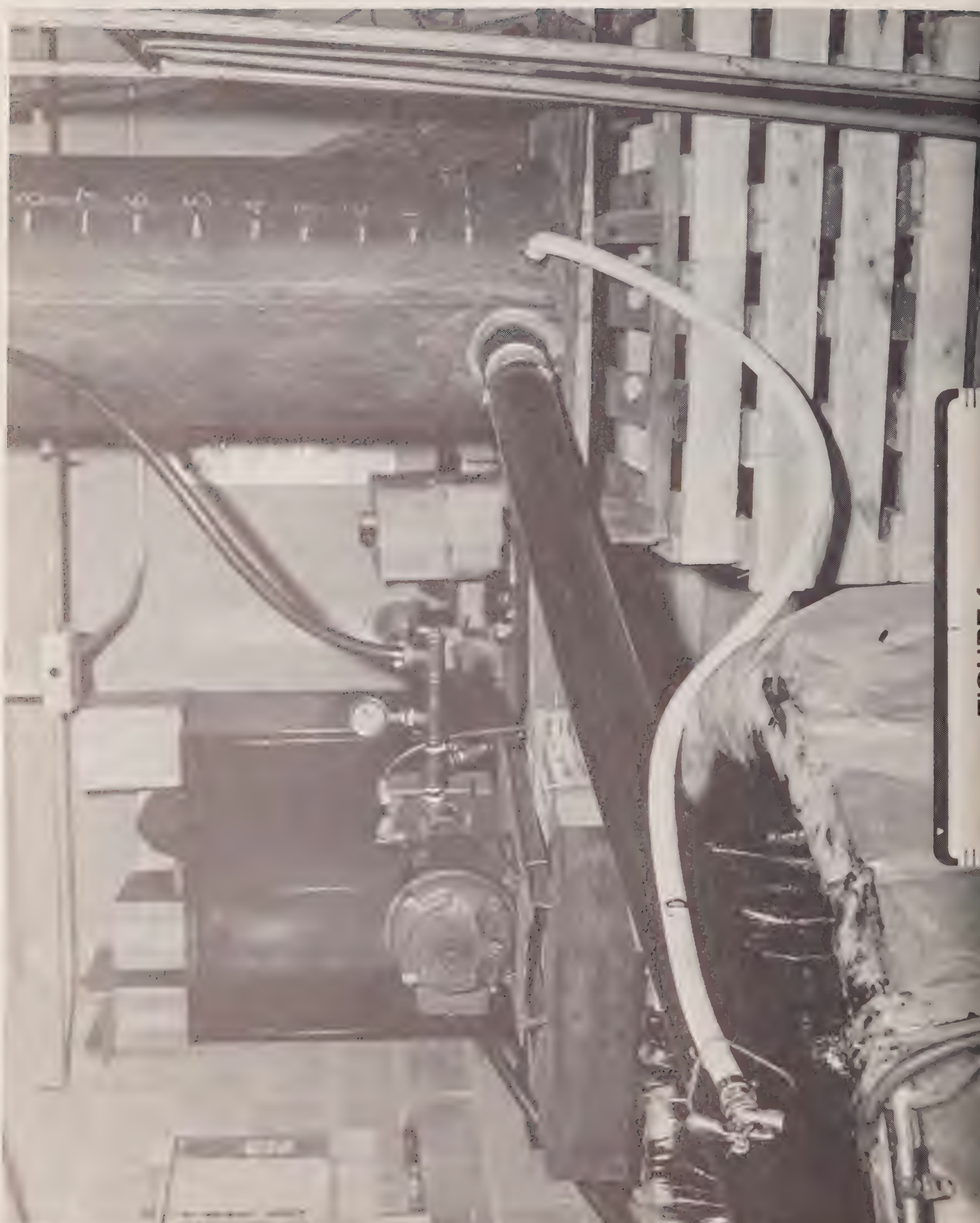


FIGURE 1

FIGURE 2.

APPENDIX II

Analysis of Bunker C in Sea Water:

Sample Collection:

Samples of the inlet and outlet of the filter were collected for the determination of inlet oil concentration and the residual outlet concentration. The sample size varied from 290 - 350 cc.

50 cc. of chloroform was then added to the sample and shaken thoroughly to insure mixing of the chloroform and Bunker C. The chloroform - oil layer was then withdrawn using a separatory funnel. A further 50 cc. of chloroform was added in two 25 cc. lots to insure complete removal of the oil from the sample collection vessel. The weight of oil contained in the 100 cc. of chloroform was then determined using a Fisher Florescence Spectrometer. This weight was then related to the ppm of oil contained in the sample.

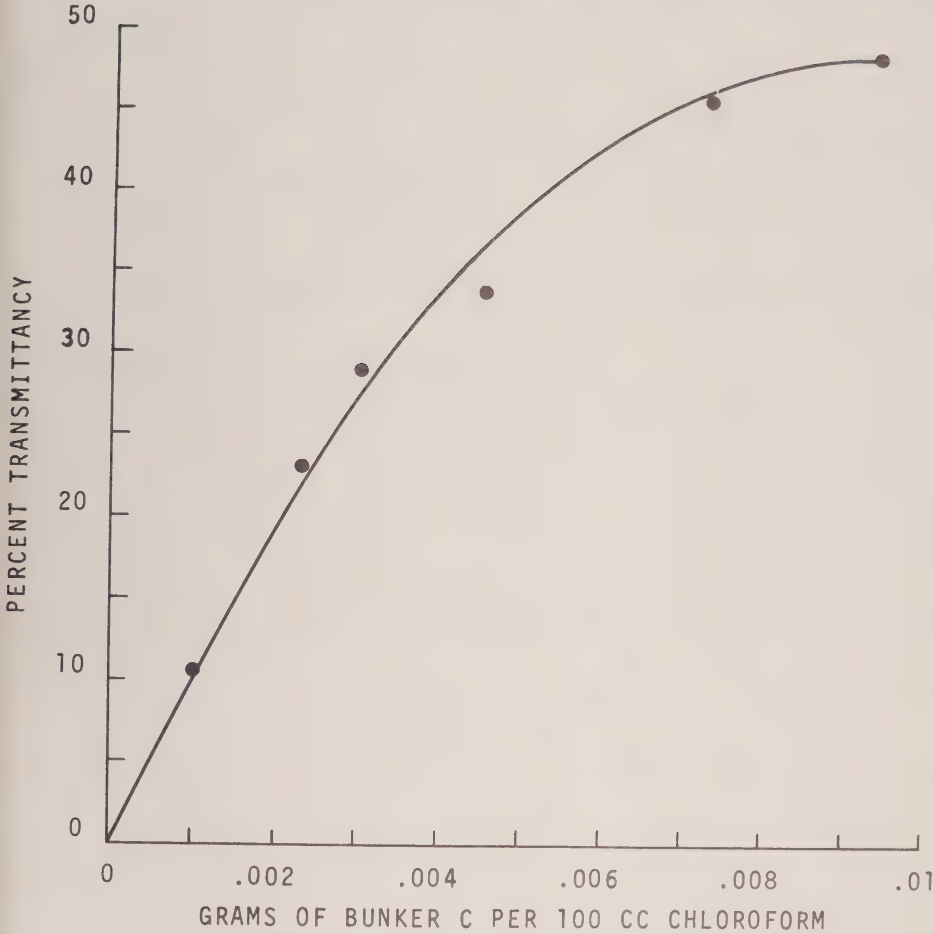
Preparation of Standards:

Standard concentrations of Bunker C in chloroform were prepared and used for the preparation of a calibration curve relating percent transmittancy versus grams of Bunker C/100 cc. of chloroform. See figure 3.

The spectrometer was used in its most sensitive range (x.001).

The instrument with the dilution factor used (100 cc.) was found to be sensitive down to 0.5 ppm of Bunker C in sea water.

FIGURE 3.


50
40
30
20
10
0
PERCENT TRANSMITTANCY
0
.002
.004
.006
.008
.01
GRAMS OF BUNKER C PER 100 CC CHLOROFORM

APPENDIX III

LIST OF ILLUSTRATIONS

FIGURE 4.

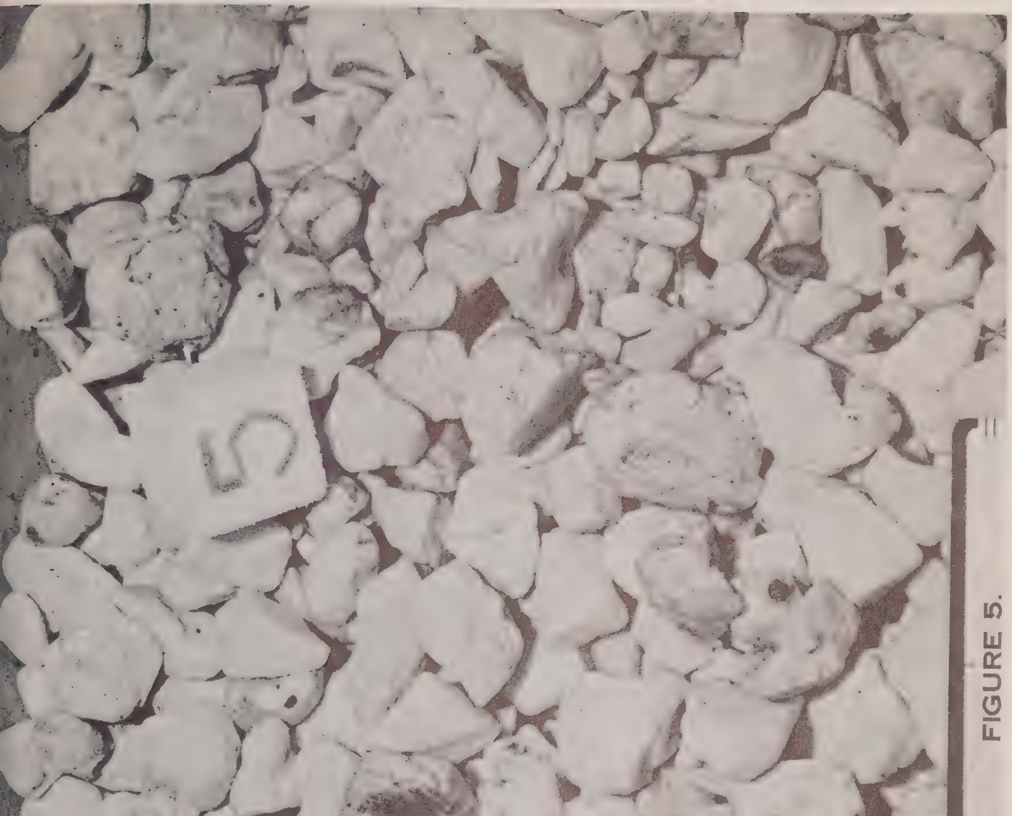


FIGURE 5.

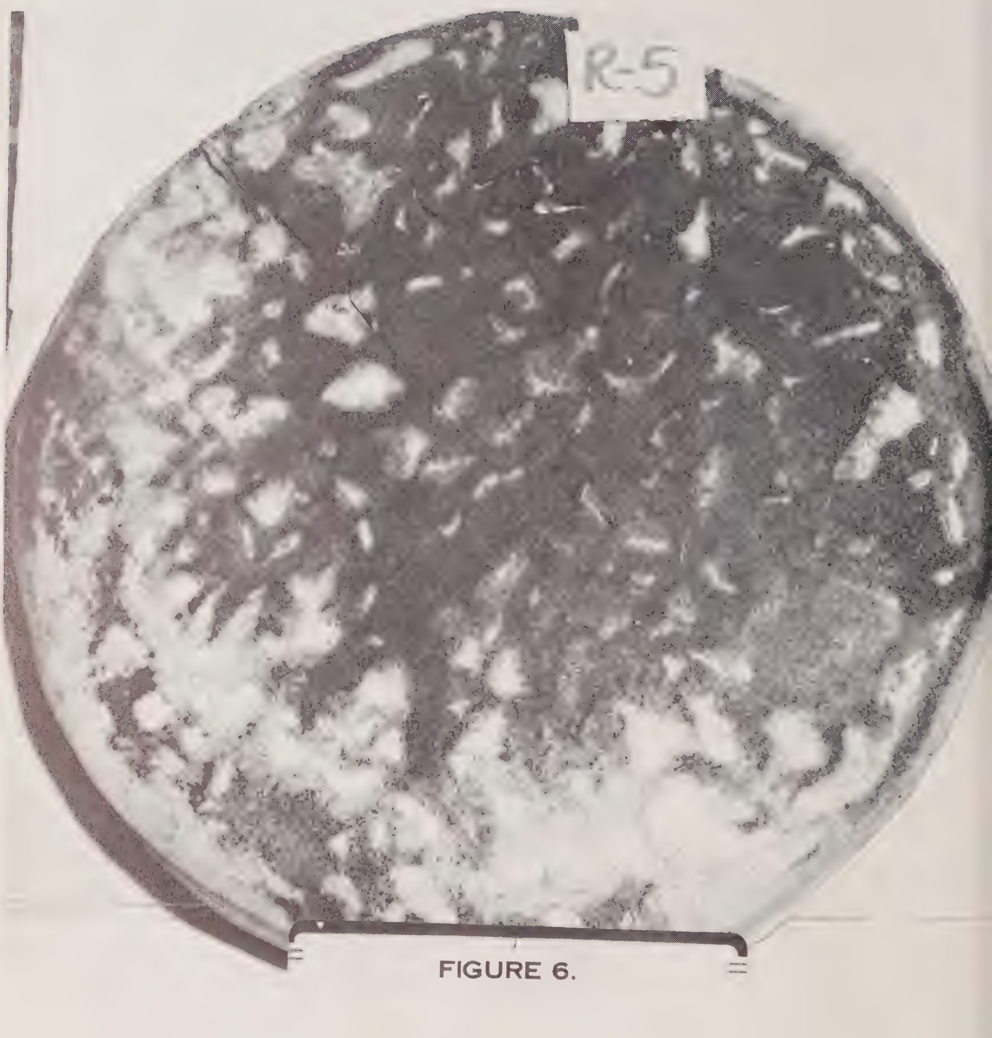


FIGURE 6.

FIGURE 7.

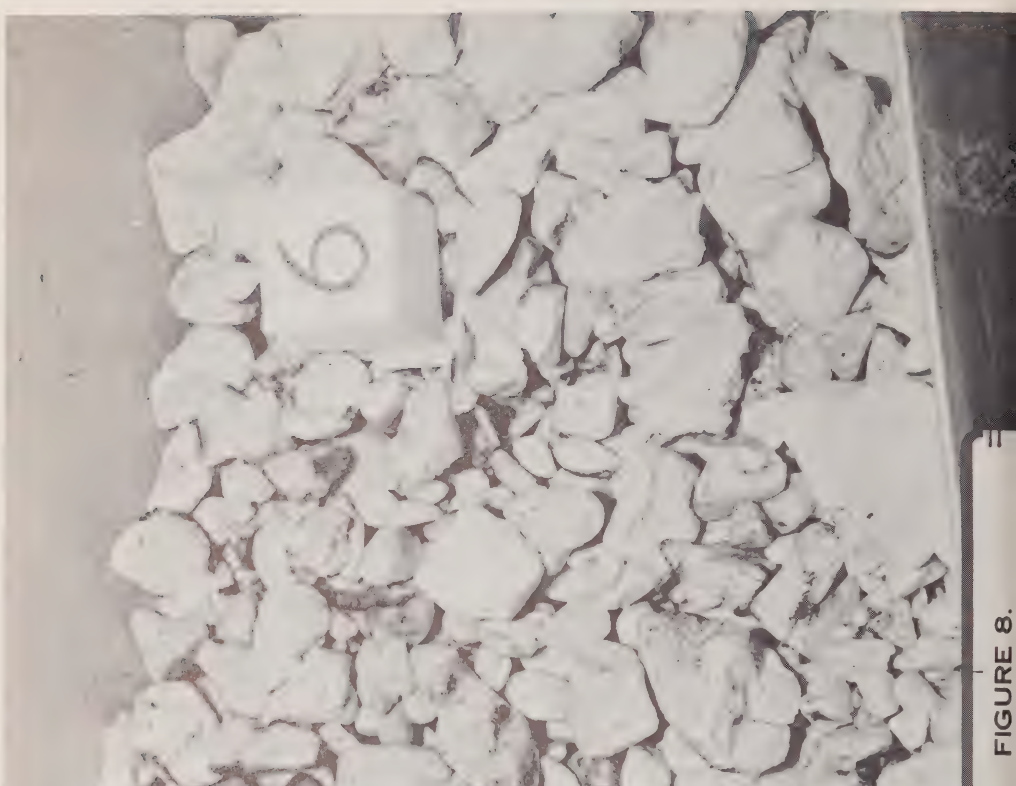


FIGURE 8.

FIGURE 9.

FIGURE 10.

FIGURE 11.

FIGURE 12.

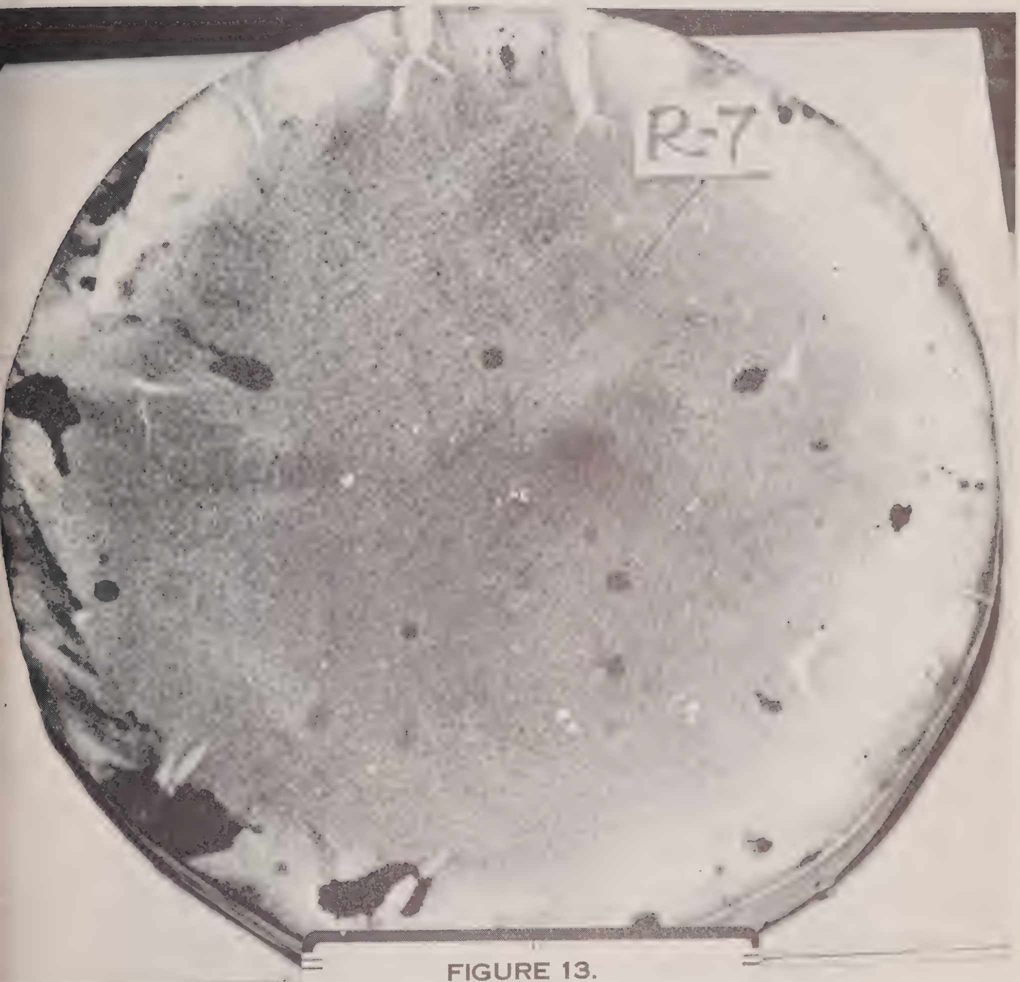


FIGURE 13.

FIGURE 14.

FIGURE 15.

FIGURE 16.

FIGURE 17.

VOLUME III

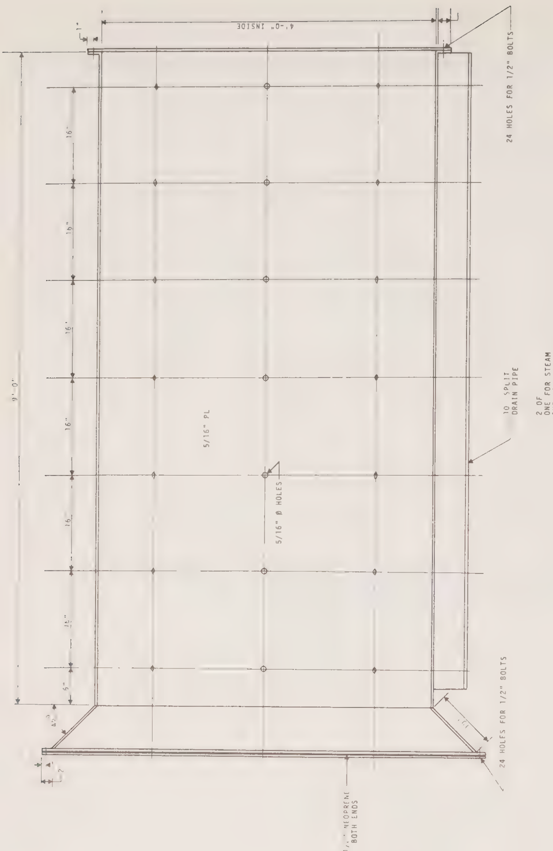
PART 8

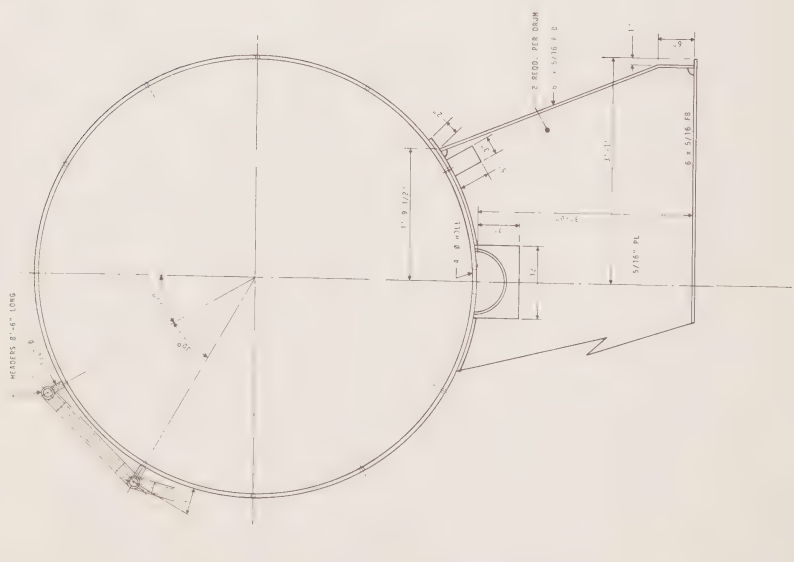
PLANS FOR FISH GEAR LAUNDROMAT

Ferguson Industries Ltd., Pictou Nova Scotia Drawing No. 3000-1538, dated 1/4/70:

FISHING GEAR LAUNDROMAT POWER BLOCK SEATING Drawing No. 3000-1517, dated 3/4/70:

FISHING GEAR LAUNDROMAT


4'-0" INSIDE
24 HOLES FOR 1/2" BOLTS
9'-0"
16"
5/16" PL
5/16" Ø HOLES
10 SPLIT DRAIN PIPE
2 OF
ONE FOR STEAM
ONE FOR HOT WATER
24 HOLES FOR 1/2" BOLTS
BOTH ENDS


2 REQD. PER DRUM
6 x 5/16 FB
3'-1"
5/16" PL
1' 9 1/2"
HEADERS 8'-6" LONG

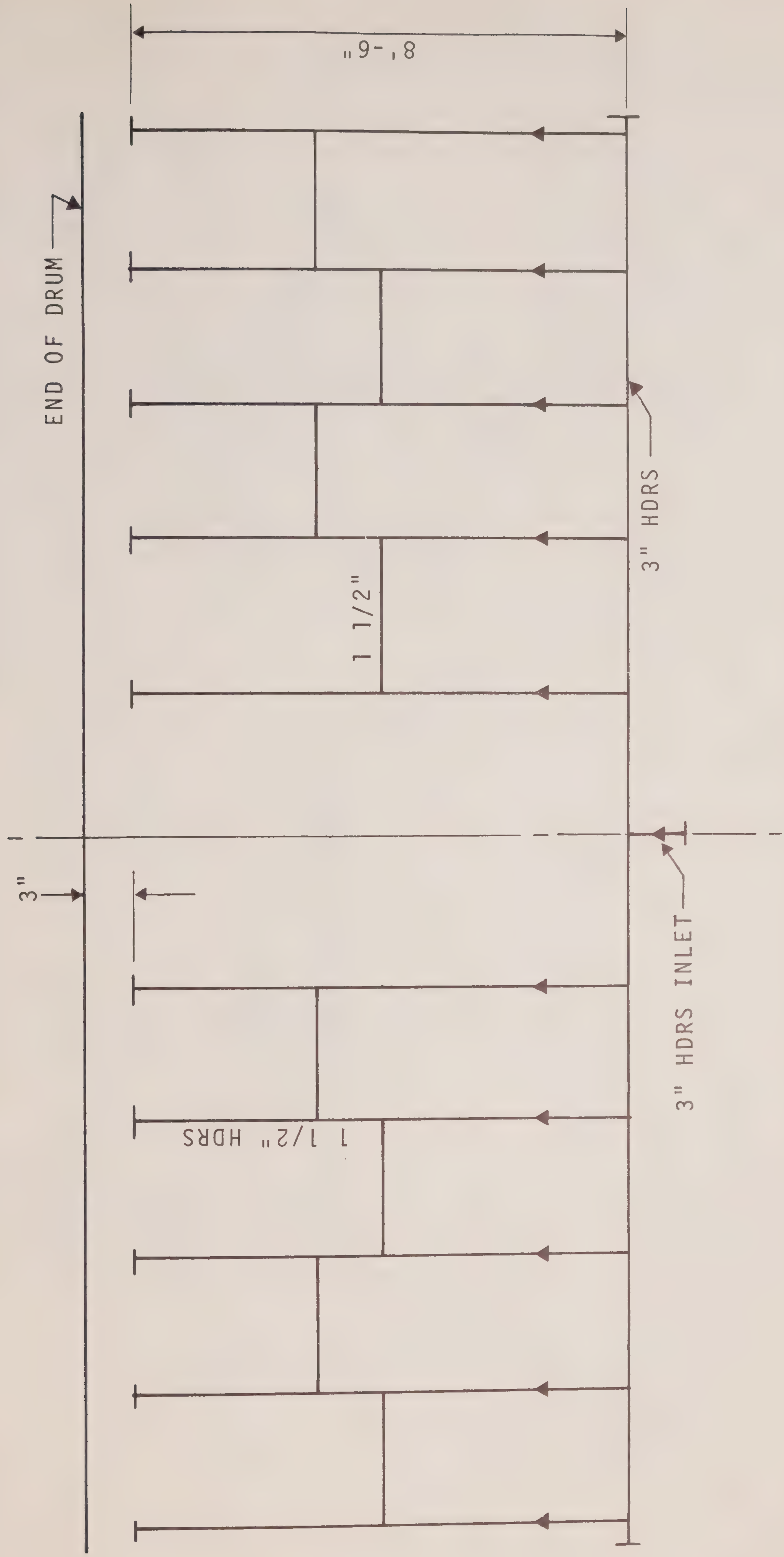
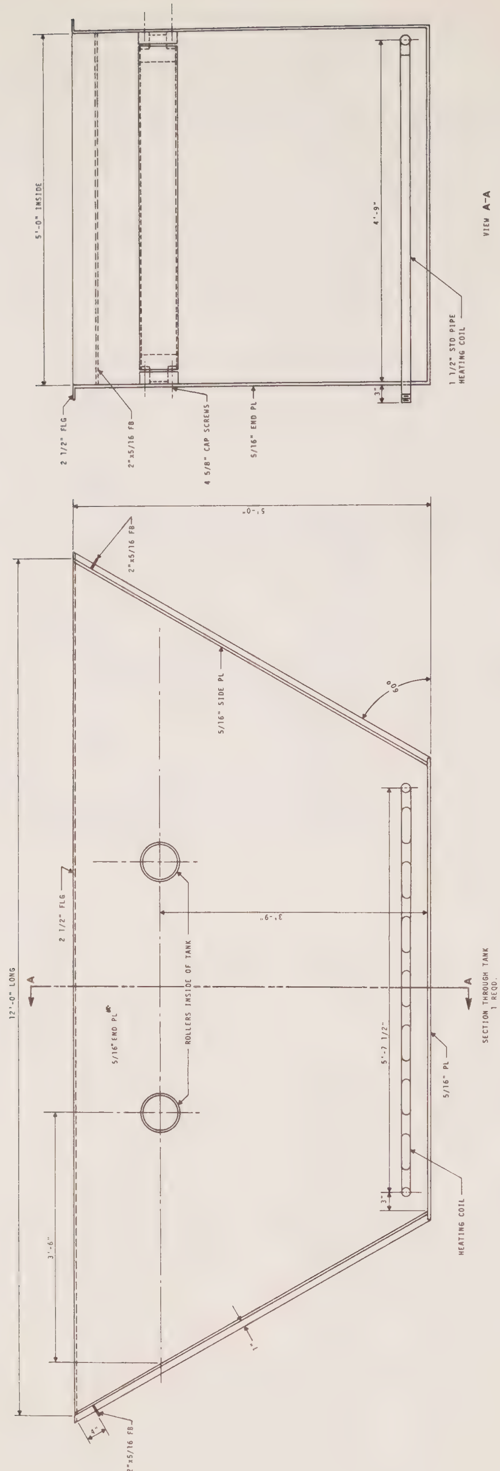
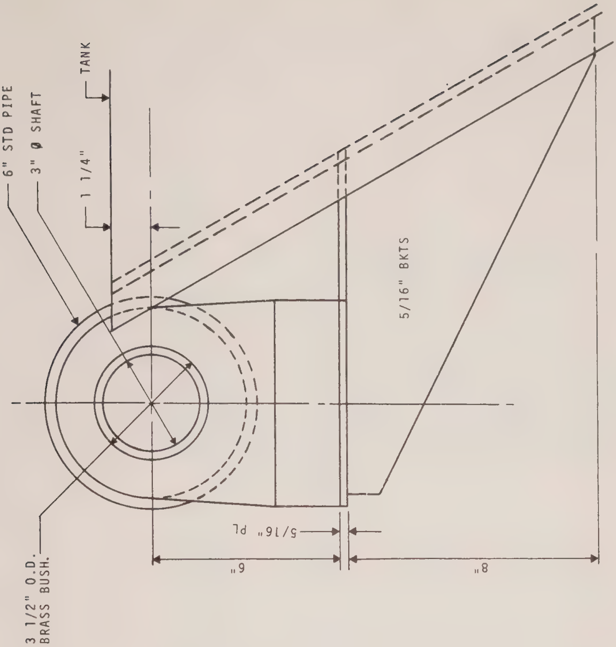


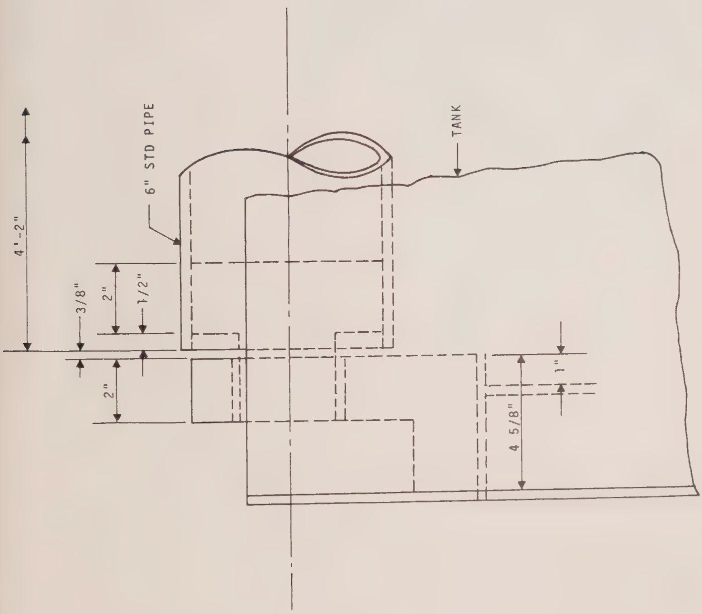
DIAGRAM SHOWING POSITION OF CONNECTIONS



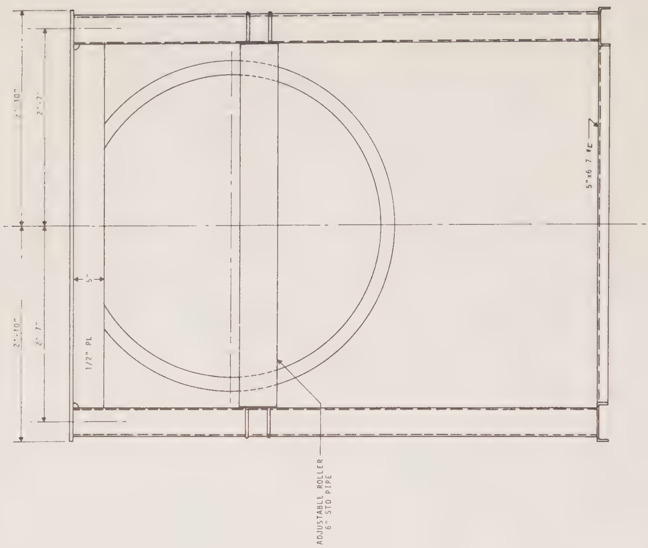
5'-0" INSIDE
2 1/2" FLG
2"x5/16 FB
4 5/8" CAP SCREWS
5/16" END PL
4'-9"
3"
1 1/2" STD PIPE
HEATING COIL
VIEW A-A
5'-0"
2"x5/16 FB
5/16" SIDE PL
60°
2 1/2" FLG
3'-9"
ROLLERS INSIDE OF TANK
12'-0" LONG
5/16" END PL
SECTION THROUGH TANK
1 REQD.
5'-7 1/2"
5/16" PL
3"
HEATING COIL
3'-6"
1"
4"
2"x5/16 FB

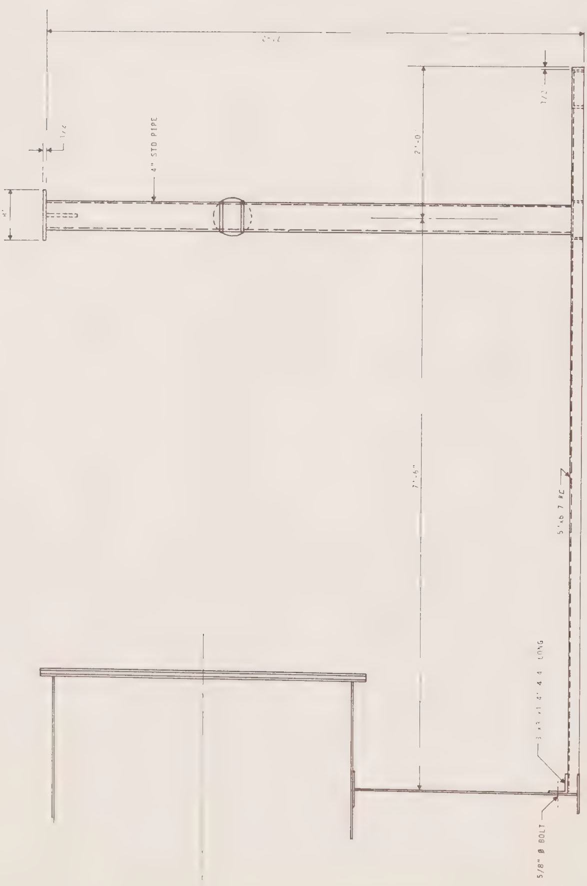


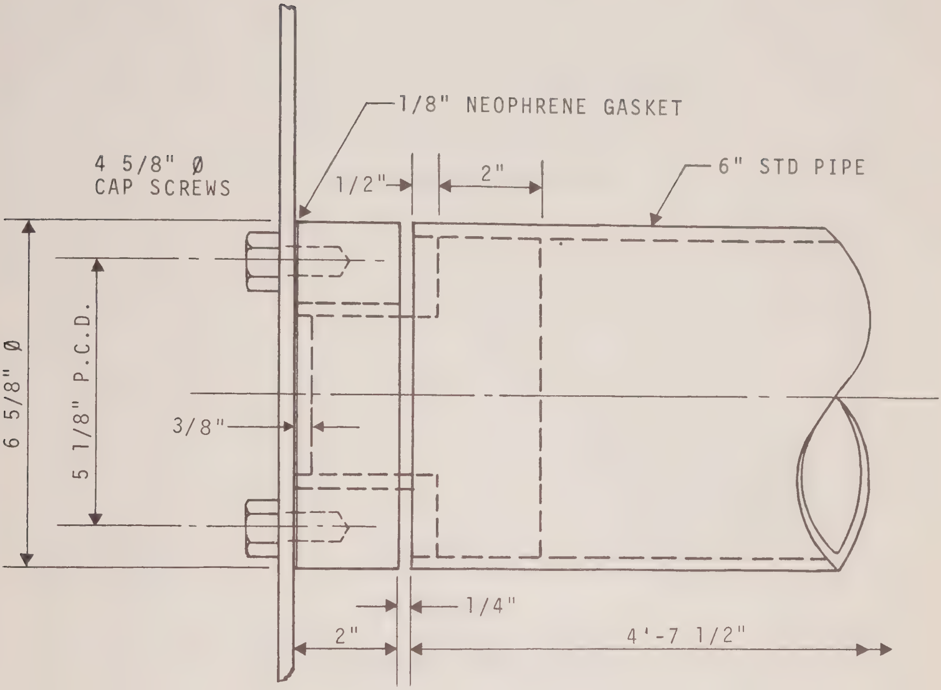
DETAIL OF ROLLERS ON TOP OF TANK



DETAIL OF ROLLERS ON TOP OF TANK


2'-10"
2'-7"
5"
2'-10"
2'-7"
1/2" PL
5"x6.7 #[
ADJUSTABLE ROLLER
6" STD PIPE


4" STD PIPE
2'-0
7'-6"
5"x6.7 #[
LONG
5/8" Ø BOLT



DETAIL OF ROLLERS
INSIDE OF TANK

VOLUME III

PART 9

REPORT ON ABSORBENTS

Report on activities in Chedabucto Bay and on related research conducted at the university of Sherbrooke

Bernard Coupal, Ph.D.
Associate professor,
College of Engineering,
University of Sherbrooke,
Sherbrooke, Que.

May 1970

List of Figures and Tables

Acknowledgment

I wish to express my most sincere thanks to Dr. W.D. Jamieson, assistant to the Director of the National Research Council, Atlantic Laboratory for his cooperation. Without his help the field tests conducted in Chedabucto Bay would not have been possible. I wish also to thank Mr. Norman Sellars and Mr. Walter Crosby for their help in carrying out the experiments.

I Introduction

Following the wreck of the tanker Arrow in the Bay of Chedabucto in February 1970, I had the opportunity to carry out some field tests on the site of the oil spill. Controlled experiments were also conducted in Sherbrooke both at the University and nearby locations.

The present report is divided into two parts and will cover both activities.

II Field Tests Conducted in Chedabucto Bay

On February 16, 1970, a call from Dr. W.D. Jamieson, assistant to the Director of the National Research Council, Atlantic Laboratory, informed me of the possibility of carrying out some experiments with peat moss in the Bay of Chedabucto. My research assistant, Mr. François d'Hennezel and I left Sherbrooke on February 17th and were in Arichat the following day. With the help of Mr. Norman Sellars, Dr. Jamieson's technician, tests were conducted on the shores of Janvrin Island. The following day a boat was rented and an experiment on open sea was performed. On February 25th, I came back to Arichat and a controlled experiment with sawdust, straw and peat moss was scheduled. Finally in the first week of March, mixtures of bunker and peat moss were used for burning experiments under various conditions.

All the field tests were planned and carried out to assess the potential of peat moss as absorbent. Previous research conducted under laboratory conditions had shown that peat moss selectively absorbs oil and repels water (1). Field tests were however necessary before reaching any conclusion.

a- *Tests conducted on February 18, 1970*

The site of the field tests was the northern shore of Janvrin island. The weather was mild and the temperature in the lower forties. In the first experiment, a patch of oil of approximately 20 square feet, and slowly moving to the shore was spread with peat moss and left for thirty minutes. Using a ¼″ wire mesh screen, two persons brought the slick to the shore by dragging it with the screen positoned vertically in the water. The mixture peat moss-bunker C did not stick to the screen and once ashore it was molded into a sphere.

The second experiment was conducted in the following way. The same screen was positioned vertically in the water (3 feet deep) and acted as a boom. Peat moss was spread ahead of the screen and a patch of oil was easily stopped by the boom. Finally in the last experiment, peat moss was spread on the shore and oil from the sea came and covered it. It was then easy to rake the beach and collect the mixture.

b- *Tests conducted on February 20, 1970*

The experiments were conducted on Janvrin island under severe weather conditions. The temperature was in the twenties and snow and ice had packed all along the shoreline.

The first experiment was planned to be performed on rather large oil slicks in order to fully test the absorbency of three materials: sawdust, peat moss and straw. Due to extreme cold weather of the previous days, it was impossible to find patches unmixed with ice and snow. After considerable search, it was finally decided to carry out experiments on oil patches exposed at low tide.

Three patches of about $5\ ft^2$ were chosen. One was covered with sawdust, the second one with peat moss and the last one with straw. The quantities used were two bags of sawdust (100 pounds), two bales of straw and two bales of peat moss. The sawdust was dry and had been brought to the site from Truro. The straw was provided by Imperial Oil and the peat moss was the commercial type used for soil amendment.

After thirty minutes, each patch was examined. The sawdust had not even stuck to the oil surface. The peat moss had stuck to the surface and the mixture could be gathered up and be shaped into a sphere without any adherence to the gloves. As to the slick covered with straw, the adherence was less and the collecting was more difficult. It is however necessary to point out that the material was no longer Bunker C oil because of its long exposure to the water and to cold weather. The mixture was of the grease type and it was impossible to assure that absorption was taking place.

In the second experiment, burning was tried. To ignite the mixture, a turbofuel was used as a starter. For the three patches, the experiments were negative. Additional tests or burning will be discussed later.

c- *Experiments conducted on March 1, 1970*

The experiments took place on Cape Auget where heavy patches (2″ thick) of bunker C oil were exposed to low tide. The tests aimed at trying to burn the deposits on the shores. Chemicals as sodium perchlorate, ammonium nitrate, metal oxyde as SiO_2 were used.

Peat moss was spread on the patches and seemed to act as a wick. The fire was started with gasoline. Burning did occur at the beginning, but the combustion was not self-sustaining. After ten minutes the fire died out. The degradation of the bunker with time and its long exposure in water are certainly two major factors. Tests were conducted at the University of Sherbrooke on a mixture 60% bunker, 40% water left outside during February for twelve days and the combustion was performed completely with only peat moss and gasoline.

d- *Experiments conducted on February 19 and March 2, 1970*

It was planned to assess the possibility of gathering oil slicks on the sea. On February 19, a boat was rented and an experiment conducted on open sea. Before leaving the docks a boom was built with ¼″ mesh size screen. The boom was twenty feet long and five feet high. Floats were fixed to the net in order to assure floating, while a chain was used as lead weight. A piece of wood was also attached to the net in order to keep the net from curving.

Once on the boat, a slick was found and ten bales of peat moss spread by hand. Here the modified snow blower would have been very useful. The boom was pulled by the boat and the recovery was very poor because the boat first divided the slick into two parts and the boom did not gather anything. On March 2nd, the same net was used but pulled by two boats. The collecting was then much more successful, even if the weather conditions were severe (wind, snow, waves).

e- *Tests conducted on April 22, 2970*

On our way to Arichat, my research assistant and I were told to go to Glace Bay and look at the beaches polluted with bunker C oil resulting from the sinking of the Patrick Morris. Once there, we visited a beach located between Glace Bay and Tonkin. The beach was spotted with numerous lumps, approximately one square inch in size. Ten men from CNR in Sydney were taken to the beach in order to proceed to the cleaning. Peat moss was spread on the beach, and mixed with the oil with the rakes. The mixture was then raked and put in 45 gallon drums. The operation was successful and peat moss was kept in nearby locations for possible future uses.

III Conclusions

Even if the number of experiments is by far very small, qualitative conclusions can be reached.

1- Peat moss behaves on the sea the way it has been found to behave in the laboratory. The first experiment seems to indicate that peat moss could be very useful in collecting oil slicks on the sea.

2- In case of oil in the shores, the hazards could be eased by previously spreading peat moss. This operation would facilitate the collecting operation.

3- Exposure to weather conditions and sea water degrades the oil and it becomes more and more difficult to absorb it. The absorbency of peat moss is rather quickly decreased as the oil changed from its regular state into a rather grease type material.

4- Beach cleaning is "relatively" easy with peat moss. Raking the peat moss and the bunker C provides mechanical energy which increases the absorption. The mixture does not stick to the rake and the technique is valid where raking is possible. On rocky shorelines, other techniques have to be experimented. In the second part of the report, a controlled experiment conducted nearby Sherbrooke will be discussed.

IV Laboratory Research Conducted at the University of Sherbrooke

Dr. Alan Young McLean from the Cleanup Technology group asked me to test the absorbency of some materials. Peat moss, silicone material, absorbent type C and a packing material were tested. The peat moss and the absorbent type C were extensively tested while a few experiments were made with the other materials. Emulsions of water and bunker C were made and mixed with either peat moss or absorbent type C in order to measure the influence of the water content on the absorbency.

a- *Absorbency of peat moss and absorbent type C*

i - Experimental procedure

The technique used was identical to the standard method of test for oil absorption of pigments by Gardner-Coleman method (2), except that it was conducted in two different ways. In the first method referred as method 1, a given amount of material (5 grams weighed to the nearest 0.1 g) was transferred in a stainless steel cup and the amount of mixture of bunker C oil and water was added at a very slow rate. Stirring with a spatula was achieved during the addition. As the particles of the absorbent became wetted, they collected in small lumps which gradually coalesced. The end point was reached when the lumps had collected into a single lump.

On the second technique referred as method 2, a given amount of mixture was placed in the container and the absorbent was added. It was found that the test conducted in this way was more suitable for both the peat moss and the absorbent type C.

The results are related to the technique used. We made a survey of the methods available and found the Gardner -Coleman method the most suitable one, because it provides mechanical energy (stirring action) as we might expect on sea (wave action) or on land (raking).

The mixtures of bunker C oil and (percentage by weight) water were made in different ration. For each mixture, agitation was achieved in order to make mixtures as homogeneous as possible.

ii - Calculations

The absorbency was calculated on a mass basis according to the following equation.

$$\text{absorbency} = \frac{\text{grams of mixture absorbed}}{\text{grams of absorbent}}$$

iii - Results

The results are given in Table 1 for peat moss and in Table 2 for the absorbent type C. Figure 1 shows the results in a graphical form. For peat moss, for a water content higher than 40% the selective absorbtion is clearly observed. First, oil is easily absorbed and then water. For mixtures higher than 70% of water, tests were difficult to conduct and reproductability was poor. Tests were made with fresh bunker C oil and tap water, and the emulsions were very much different from what was found on the shores of Ched-

abucto Bay. Dr. McClean sent us a sample and a test has been carried out with it. The mixture was semi-solid and very viscous. The figure from the test gave 13.9 grams of mixture "absorbed" by gram of peat moss used. This value gives a water percentage of 40% according to the curve given in figure 1. Simultaneously a sample was heated at 220°F and kept at this temperature until the sample experienced no change in weight. The water content was calculated at 40%. The results show that a maximum in absorbency is reached for a water percentage of around 40%. It is difficult to advance any explanation but there is certainly an interaction between the bunker C oil and the water. Some samples of dried and wet (40% water) peat moss were studied with an electron microscope by my colleague, Dr. Maurice Ruel. The material is made up of very long pores and it has been observed that the addition of water up to a certain quantity enlarges the diameter of the pores. Beyond that point water fills the pores completely and selective absorption takes place. Figures 2 and 3 show two pictures of a pore observed with an electron microscope.

The absorbent type C sold by Cleanwater Inc. show a constant absorbency versus the amount of water in the emulsion. The density of absorbent C was measured and found equal to 0.0655 while the figure for peat moss is 0.0855. It is then not better than peat moss on a volume basis. The absorbent type C is more expensive than peat moss and does not present any economical advantage. Since it is non inflammable, the mixture oil-absorbent cannot be burnt.

b- *Absorbency of packing material, eelgrass, pine needles and synthetic fibres*

i - Experimental procedure

In order to measure the absorbency of those materials not available in granular form it was necessary to use a different technique. The method consisted in immersing a given weight of the material into the oil for a given amount of time, pulling it out and leaving it until dripping stops. By weighing the sample before and after the immersion, the absorbency was then evaluated. The sample was put into a cylinder of 8″ in diameter and 2″ in height, made of a stainless steel wire mesh. The cylinder was weighed (M_1) and then submerged into the oil and weighed again (M_4) The difference ($M'_4 - M_1$) gave the amount of oil "retained" by the cylinder. The sample under study was placed into the cylinder and weighed (M_2). The cylinder is then immerged in the oil for thirty minutes (found to be saturation point) and pulled out and allowed to drip for three and a half hours, and weighed (M_3). The weight (M_1) was measured before each test, because it changed with the number of experiments. Oil in a semi-solid phase coated the mesh.

ii- Calculations

The different weights are used to calculate the absorbency according to the equation:

$$R = \frac{M_3 - M_2 - (M'_4 - M_1)}{M_2 - M_1}$$

iii- Results

The results are presented in Table 3. The synthetic fiber gives a very good absorbency but it is far from the specifications (20 - 30 times its weight). It would be necessary to know the method used and the type of oil in order to fully establish a comparison because of lack of data.

c- *Effect of temperature and salt water on absorption*

The temperature is an important variable because it affects the viscosity of the oil. The higher is the viscosity, the slower is the rate of absorption. For bunker C oil, the viscosity at 70°F was measured with a Brookfield viscometer and found equal to 15,000 centipoises. In the Bay of Chedabucto the temperature of some oil slicks were measured and found in the lower thirties. At such low temperature, the bunker C oil becomes a semi-solid and absorption is very slow.

Table 1

Absorbency of peat moss

Mixture Bunker C - water $\%H_2O$	Absorption Method 1	Absorption Method 2
	g of mixture absorbed / g of oil absorbed	
0	7.7	8.2
10	9.6	9.8
13	11.2	12.5
25	14.6	15.2
33	14.9	15.8
40	15.8	16.8
50	14.8	13.8
60	14.0	14.8
70	12.8	13.7
80	13.4	14.1
100	10.0	10.4

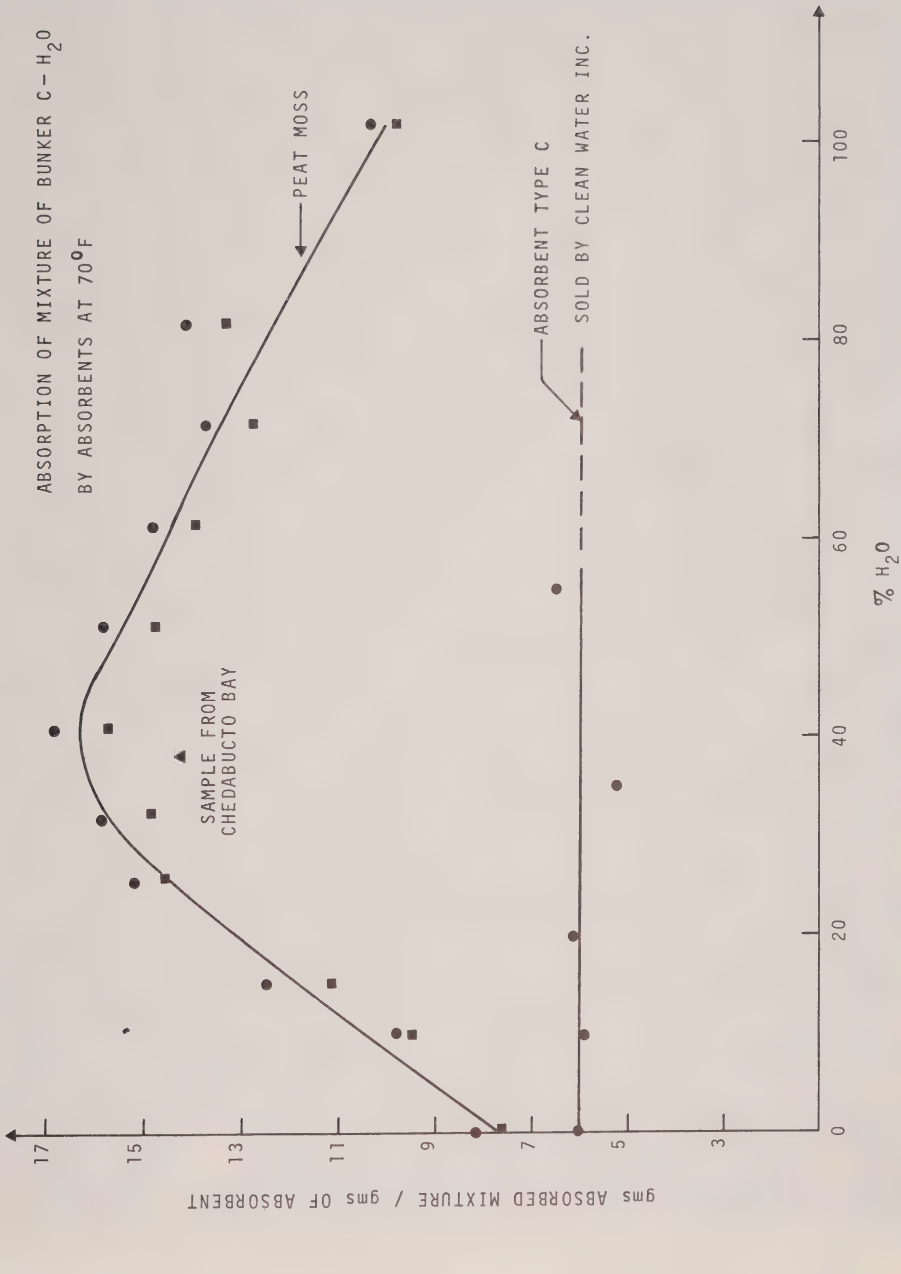
Table 2

Absorbency of absorbent type C sold by Clearwater Inc.

Mixture Bunker C - water $\%H_2O$	Absorption
0	6.01
10	5.95
20	6.15
35	5.25
55	6.50 (1)
75	not measured (1)
100	not measured (1)

Test concluded with sample from Chedabucto Bay: 6.57

(1) Since the absorbent does not absorb water it was impossible to measure for water content higher than 53%



ABSORPTION OF MIXTURE OF BUNKER C – H_2O
BY ABSORBENTS AT 70^oF
PEAT MOSS
SAMPLE FROM CHEDABUCTO BAY
ABSORBENT TYPE C
SOLD BY CLEAN WATER INC.
gms ABSORBED MIXTURE / gms OF ABSORBENT
% H_2O
17
15
13
11
9
7
5
3
0
20
40
60
80
100

Figure 1.

Figure 2. Sample of peat moss observed with an electron microscope enlargment: 14,000

Figure 3. Sample of peat moss observed with an electron microscope enlargment: 66,000

Table 3

Absorbency of materials

Material	M_1	M_2	M_3	R
Eelgrass	1.285	1.318	1.475	6.2
pine needle	1.290	1.313	1.425	3.3
absorbing fiber from Collins and Aikman (30″ x 18″ piece)	1.295	1.308	1.475	11.7
commercial peat moss	1.295	1.397	2.090	6.5

Emulsions with salt water were made and absorption tests conducted. The results did not differ from the figures determined with fresh water.

d- *Experiment conducted on rocky shoreline*

During my last visit to the Bay of Chedabucto, I noticed large rocks exposed at low tide and completely covered with bunker C oil. The layer was semi-solid and seemed stable at the prevailing temperature. There is however no doubt that the oil will flow back to the sea during the hot summer days.

A controlled experiment was then scheduled in Sherbrooke in order to test a technique of steam cleaning followed by an operation of recuperation.

A farmer in the country nearby Sherbrooke agreed to rent us part of a stream located on his land. Half submerged rocks located in the stream were then covered with bunker C oil and booms were installed at proper locations in order to prevent the oil from polluting the remaining of the stream. A steam jenny, a portable mud pump and steam generators were brought up on the site of the experiment. Peat was spread on the rocks which were then steam cleaned using the steam jenny. The bunker C oil flowed down the rocks and combined with peat moss. Additional quantity of peat moss had been placed ahead of the boom. The current brought the bunker C oil and the peat moss to the boom where everything was stopped. With the mud pump we succeeded in recuperating the mixture. The technique did work for large rocks but is certainly not very rapid. Figure 4 shows a sketch of the operation.

V General Conclusions

From what I have seen in the Bay of Chedabucto, the best plan is to remove the oil entirely from the water. This may be done by spreading material on top of the oil which absorbs it and forms a mass which may fairly easily be removed from the surface of the water. The use of this method in open water must be facilitated by proper installation of booms and barriers. A good absorbent must possess good properties as regards sucking up oil and in addition it must be able to remain afloat sufficiently long on the surface of the water, so that the mixture it forms with the oil may be removed before it sinks.

The first of these conditions is exceptionally well fulfilled by peat moss. As far as the second condition is concerned an air-dried peat to approximately 35% water content is very suitable. Commercial peat moss sold in plastic bags is dried to that extent. Regarding smaller disasters arising from oil it would be quite possible to keep bales of peat moss in harbours and other suitable places, where oil is handled in great quantity. For crude and any lighter oil, the absorbtion by peat moss is very fast and the absorbency may go up to twice the absorbency of straw. It should be possible by using peat as absorptive agent to prevent industrial oils and oils used by garages from getting into our waterways by way of the ordinary sewers.

For bunker C oil at temperatures prevailing in the winter in Chedabucto Bay, the first hours were crucial. The bunker C changed from its regular state into a semi-solid water in oil emulsion. Any absorbent including peat moss is not very effective after a certain time.

Sandy beaches polluted by oil can be relatively easily cleaned with peat moss. The operation is efficient and must be done as soon as possible, following the spill and thus preventing oil from getting into the soil. According to swedish estimates, 0.01 - 0.02% of the entire amount of oil handled in Sweden goes into the soil. This would mean, as far as Sweden is concerned, a quantity of 2 - 4 millions of pounds of oil getting into the soil every year and contaminating the ground water. On rocky shorelines, the only technique I have experimented consists in steam blasting followed by the recuperation of the mixture formed by an absorbent and the oil.

From an economical point of view, the use of peat moss as absorbent is very

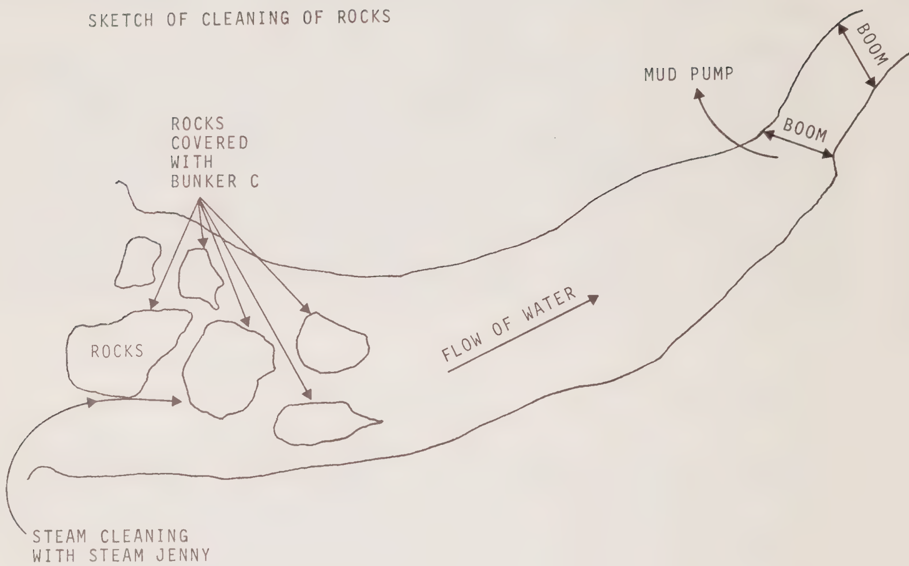


Figure 4. Sketch of cleaning of rocks

competitive. There is no figure available for Canada, but in Sweden according to their calculations, the cost of absorbing one cubic metre of oil by means of factory made absorpitive amounts to 2000 - 4000 Swedish crowns, the corresponding figure for peat being 150 - 200 Swedish crowns (4).

VI Future Work

Disasters similar to the sinking of the tanker Arrow are more and more possible because the volume of the oil handled every year increases. Research should be continuously carried out in the field of oil spill cleaning. Collecting techniques and boom technology should be two important research avenues and cooperation should be established with people already active in the field (3, 4). Peat moss as absorbent certainly presents many advantages. Field tests under different conditions should be conducted in order to find the most efficient technique. Sweden in particular is very active in the field and they found that peat moss is a very good "aid" in oil cleaning techniques (4).

Personally I am now deeply concerned by the problem. My research assistant, Mr. Francois d'Hennezel is currently undertaking a complete statistical design of experiments in order to assess the influence and the interaction of the nature of the oil, the influence

of temperature and the importance of the moisture content of peat moss on the absorbency of peat moss.

Moreover I am currently conducting a comparison of the relative effectiveness between various products together with relative costs. Such a study should be carried out both under laboratory and field conditions (5).

References

1- Patent Pending 076,409 B. Coupal, A. Marson, F. d'Hennezel.

2- ASTM - D1483-60.

3- The Financial Times, February 11, 1970.

4- OY Kvartto AB, Kelsinki, 1969.

5- Mr. H. Bernard, United States, Department of the Interior.

VOLUME III

PART 10

REPORT ON SLICK LICKERS

Port Hawkesbury, N.S.

April 27, 1970

THE SLICK LICKER

Its Origin, History, Manufacture and Employment in Chedabucto Bay, N.S.

By: R. B. H. Sewell

April 27, 1970

THE SLICK LICKER

INTRODUCTION

Operation Oil provided the opportunity to demonstrate the fact that the "oleovator" otherwise known widely as the "Slick-Licker" and the "Oilevator" could pick up the very high viscosity fuel oil from the tanker "ARROW" which was floating in various areas around Chedabucto Bay. The presence of large quantities of sea weed and other accumulated seaborn materials complicated the pick up job and made minor modifications to the first "Slick Licker" on site desirable.

The origin, history, and employment of the "Slick Licker" will be dealt with in that order below:

Origins

The "Oilevator" had its beginning in a request from the Office of the Command Technical Officer and the Command Fire Chief of the then RCN to the Pacific Naval Laboratory (which has since become the Defence Research Establishment (Pacific) of the Defence Research Board, for assistance in the development of a system to deal with oil spills which resulted primarily from the transfer of petroleum products, mainly fuels in Esquimalt Harbour.

Consideration of the problem made it appear that the system should consist of two main elements. These being (1) a floating boom with pendant skirt (which could be inflatable) for containment and (2) a device for picking up the oil thus contained from the water surface. As the boom was being made under CTO authority, the laboratory effort was confined to oil pickup.

It finally occurred to the writer that a system based on preferential wetting might have something to offer.

This model worked well and was able to produce a very clean separation of oil from water. The range of oils covered ran from light diesel oil to Bunker C.

This part of the work was described in Pacific Naval Laboratory Materials Report 61-B entitled "Absorption Device For The Removal of Flammable Spills From Water Surfaces - by R.B.H. Sewell" resulted in the issuance of Canadian Patent No. 735254 entitled "Device and System for Handling Spill".

Following the Torrey Canyon grounding, it was decided by the Director General of the Defence Research Establishment Pacific (Mr. P. F. Chinnick) that the production of a full scale working model be undertaken. The work was largely completed by early 1969 and trials of this machine ashore at the Damage Control School Colwood V. I. B. C. were undertaken in March 1969. Further trials were undertaken in Esquimalt Harbour in April 1969. The trials appeared to bear out the expectations engendered by projections based on the results obtained with the laboratory scale model. This work is briefly described in DREP Materials Report 69-J and is entitled "A Full Scale Device For The Removal of Oil From Water Surfaces".

Following these successful trials, the machine (Slick Licker) was placed in storage.

A short time later, Canadian Patents and Development Ltd. licensed a company known as R.B.H. Cybernetics Patents and Processes Ltd. of P.Q. Box 4205, Postal Station "A", Victoria,B.C. to manufacture and sub-license the manufacture of "Oilevators" now widely known as "Slick Lickers"throughout the world. This company had produced and

demonstrated two second generation "Slick Lickers" and was in the process of completing a third when a call from Dr. H. Sheffer V/C D.R.B. of the "Operation Oil" Task Force was received at the Defence Research Establishment Pacific in the latter part of February, 1970. Dr. Sheffer requested that immediate steps be taken to determine whether or not the DREP developed "Slick Licker" could pick up at a significant rate Bunker fuel of the viscosity carried by the tanker "ARROW" from a water surface.

The requested trials were undertaken and on March 4, 1970, successful trials using Gulf Bunker 6 fuel oil on water cooled to approximately 32 - 33°F. by the use of three tons of ice were completed at the Damage Control School, Colwood, V.I., B.C.

Dr. Sheffer then directed that the machine (Slick Licker) be brought to Chedabucto Bay. For various reasons including weight of the machine, length of belt, etc., it was deemed that the DREP machine would be unsatisfactory. Arrangements were, therefore, made on a "no strings attached basis" for the loan of a second generation "Slick Licker" from the above mentioned company.

The borrowed machine was flown by Canadian Forces Buffalo Aircraft from Vancouver, B.C. to Sydney, N.S., where it arrived the evening of March 10, and was transported to Port Hawkesbury, N.S. by truck on the morning of March 11, 1970. On Thursday, March 12, 1970, the "Slick Licker" was placed on board a 27 foot self-propelled barge (S.P. barge) and a plywood box was built to hold about 45 gallons of material. On Friday, March 13, 1970, the barge with Slick Licker aboard was towed to the inside of a small jetty about three miles west of Arichat. Shortly after arrival, the "Slick Licker" engine was started, the clutch engaged and very shortly the wooden box contained 45 Imperial gallons of viscous oil well loaded with sea weed. No accurate determination of delivery rate was possible here as the matter was picked up in several bites. Dr. H. Sheffer of D.R.B. attended this demonstration.

On Sunday, March 15, 1970, another demonstration of the "Slick Licker" was put on in "The Basin". On this occasion, the pick up end of the machine was dipped into a mixture of oil, seaweed and ice. So much material was picked up that the twin V-belts in the drive began to slip. Again, no meaningful measure of pickup rate was obtained as the operation period was intermittent. However, this second demonstration again showed that the machine could pick up almost anything. Dr. P.D. McTaggart-Cowan, Dr. H. Sheffer and Captain M. Martin attended this demonstration.

The following day (Monday, March 16, 1970) the Task Force decided that three "Slick Lickers" in all would be required and that construction of these machines should be done locally. It was also decided that the borrowed machine should be modified to allow it to unload directly into 45-gallon drums and that more idler rollers to provide greater belt support should be added and a more positive method of drive provided.

Manufacture of Machines

Investigation of the facilities at the Port Hawkesbury Shipyards Ltd. showed that the machines could be built there. A sub-license agreement to manufacture "Slick Lickers" on a royalty free basis was arranged accordingly between R.B.H. Cybernetics, Patents and Processes Ltd., of P.O. Box 4205, Postal Station "A", Victoria, B.C. and Canadian Patents and Development Ltd. of Ottawa, Ontario and The Port Hawkesbury Shipyards Ltd. of Port Hawkesbury, N.S.

Orders were placed for all the materials deemed to be required for the construction program. As can be imagined, a large part of the materials and components required had to be brought in from other cities. The delays encountered with some of these deliveries were considerable.

In general, the shipyard staff did very well with the (to them) entirely new problems posed them by this manufacturing program.

By April 1, 1970, the modifications to the original "Slick Licker" had been completed

to the extent they could, pending delivery of new clutches, sprockets and chain for the positive drive. In other words, the new idler rollers had been added and the frame height increased to allow unloading directly into 45 gallon drums (a very successful trial of the machine on S.P. barge was held off Rabbit Is. on April 1, 1970 when several drums of heavily oiled seaweed were picked up. One of these drums was filled in a minute - however, V-belt slippage occurred when water and oil got on the V-belt pulleys).

The first of the new third generation "Slick Lickers" which had been completed on April 7, 1970 was run in on April 8 at the shipyard and was put aboard one of the 27 foot S.P. barges.

The second new machine was completed on Sunday, April 12, 1970, and the third new machine was ready for shipment on Saturday, April 18, 1970.

Employment of the Slick Lickers

As developed, the basic units (four in number) consisted of a barge (or catamaran) on which was mounted a Slick Licker (Oilevator) accompanied by an LCM equiped with cargo handling gear.

The Slick Lickers delivered the picked up oil, oil plus seaweed or oil plus everything into 45 gallon drums which were furnished with polyethylene liners. When a Slicker carrying barge had filled its stock of drums, these would be transferred to the accompanying LCM. New drums would be picked up as part of the exchange. The picked up material was delivered by truck to selected sites.

The whole "Slick Licker" fleet was divided initially into two squadrons, each made up of two "Licker" units. These were dubbed the "North" and the "South" Squadrons, and were under the commands of Captains Greenham and Stuart, respectively.

Most of the work done by this fleet was (and is) by the nature of things around Chedabucto Bay, at the time they came on the scene, confined to working very close in shore. (The S.P. barges on which three of the "Lickers" are mounted and the catamaran on which the fourth machine is mounted are well suited to this requirement).

Since much, if not most, of the material picked up by the "fleet" was (and is) oiled seaweed, some guiding of the oiled weed to the pick up end of the "Licker" conveyor was (and is) required.

The particular nature of this enterprise is well illustrated in the photograph.

Conclusions

i) The "Slick Lickers" were in the right place at the right time.

ii) The performance of the machines at the date of writing (April 28, 1970) seems to have been good and their teething pains minimal (two clutch adjustments, one belt change and one broken roller on the original machine plus a broken cable on the belt frame angle controlling system).

iii) The effectiveness of the combination of preferential wetting for separation plus conveyor materials handling seems evident on the basis of the Chedabucto Bay work.

Future Work

The untilled regions here are great. Some of them are:

i) Addition of heat sources through enclosure either of the "Slick Licker" or of the platform on which it rests to allow effective use in the Arctic or other not well heated regions.

ii) In-plant applications (of which there should be several) Refinery applications are being worked on now.

iii) In-ship applications (e.g. tank and bilge clean up to minimize overboard discharge) some work has already been done at DREP on this one.

iv) The development of a matching system or systems involving containment, pickup and disposal. Much could and should be done in this area. For example, harbours could be partitioned off through the use of bubble curtains and then a sweep using either a floating boom or a travelling (towed) bubble curtain could be used to move and guide contained spills with pickup by “Slick Licker” to follow.

Acknowledgement

Assistance has been freely given by many people in the course of the events described above and this help is gratefully acknowledged. There is one person, however, to whom special thanks are extended. He is Mr. Simon P. Nelson of DREP. Without his impressive knowledge of applied mechanics this venture would have been much more difficult.

VOLUME III

PART II

REPORT ON STEAM CLEANING

REPORT ON STEAM CLEANING OPERATIONS

FOR PROJECT OIL TASK FORCE

J. Magill

Towne Building Services

Truro, Nova Scotia

Steam cleaning operations carried out for Project Oil under direction of Project Oil Task Force by Towne Building Services, Truro, N.S.

Nature of Problem -

A method was needed to remove accumulated bunker oil which had floated ashore from the wreck of the tanker "Arrow" and coated docks and jetties used by fishermen and the general public with up to ½ an inch of tough, weathered Bunker 'C' oil.

August 1970

CRITERIA FOR CLEANING METHOD

1. NO DETERGENTS OR SOLVENTS

   - No cleaning methods that increased pollution would be tolerated. The great quantities of detergents or solvents that could have been used would undoubtedly have had a worse effect on marine life than the oil itself, which was really more of a nuisance to man than a menace to sea life.

2. HARDY, RELIABLE EQUIPMENT FOR OUTDOOR USE

   - Because of the wide range of weather conditions, from bright, warm sun to pouring rain, high winds to fog. & the necessity to get the job done fairly quickly -- the cleaning method had to be such that it could operate in almost any weather conditions. Spare parts would be a problem too so the need for such had to be eliminated as much as possible.

3. APPLICATION BY UNSKILLED LABOR

   - It was hoped a method could be found which would not require special training and which could be applied by relatively unskilled labor.

4. EASE OF LOGISTICAL SUPPORT

   - Cleaning materials had to be readily available and easily supported along the entire route of the cleaning operation.

5. PORTABILITY

   - A further criteria was that the method be portable on water aboard shallow draft vessels, this being the most logical way to approach the docks and jetties.

STEAM CLEANING MET THE CRITERIA

1. No detergents or solvents -- Steam's effectiveness resulted from both high heat and high pressure. Heat melted the oil and pressure sheared the softened oil away. Steam was generated from fresh water without even a spoonful of detergent being used in the whole operation.
2. Hardy, reliable equipment for outdoor use -- Steam generation equipment operated in almost all weather conditions encountered during the operation. The equipment itself was very reliable and very few replacement parts were needed.
3. Application by unskilled labor -- Only one skilled maintenance man was required to oversee the operation of the steam generating equipment. The steam gun operators being drawn from a variety of non-relevant occupations.
4. Ease of logistical support -- Logistical support for the steam generating equipment consisted of supplying fresh water, stove oil, and gasoline, all of which were readily available all around Chedabucto Bay.
5. Portability -- Steam generating equipment was light in weight and compact enough to be carried on small craft.

SETTING UP A WORKING SYSTEM

An original 30 day or 240 hour operating test was begun starting with 2 model 750 Hy-Pressure Steam Jenny's mounted on the rear deck of a 38′ Cape Island type boat. The equipment loaded aboard consisted of the 2 steam generators, a portable 2500 watt

electrical plant, a 100 gal. storage tank for stove oil fuel and 5 - 200 gal. storage tanks for fresh water. Fully loaded our equipment weighed approximately 7 tons.

We began work on the Fisheries Experimental Wharf at West Arichat. This wharf was badly fouled on both sides and on top and was difficult to clean. In addition the small harbour created by the wharf was very shallow and at low tide 80% of the wharf was inaccessible due to lack of water to float our craft. During the few days spent there our rudder was damaged while manoeuvering in shallow water. The difficulties experienced indicated that the Cape Island boat's draft would be presenting problems often since many of the jetties to be cleaned were in shallow water.

A specially constructed catamaran was available at the site which was ideally suited to our needs. She had ample deck area (14′ x 26′) and good flotation, Our equipment was loaded aboard, Mobility for the 'Cat' was provided by an L.C.M. which not only towed the 'Cat' from job site to job site but which also supplied us with fresh water. An L.C.M. has a carrying capacity in her side tanks of 7 tons of fresh water. The L.C.M. pumped water into her own tanks from public water sources, fish processing plant docks, and even fresh water streams emptying into the perimeter of Chedabucto Bay. Fresh water was then re-pumped into the tanks aboard the 'Cat' as required.

The original tips supplied with the steam guns were round with about 5/8″ I.D. The force of the steam was too concentrated and not practical for our project. New tips were ordered which spread the steam force across a 4″. long opening only 3/32″ wide. These tips were flatter and much more efficient, operating much like a mechanical scraper. More equipment was needed also to speed the pace of the clean-up. Two more steam generators were loaded aboard along with another set of fresh water tanks and a fuel storage tank.

EFFICIENCY RATE AND CONTROLLING FACTORS

Under ideal conditions, with a fully exposed surface at low tide, a flat vertical surface to be cleaned, with a more or less uniform coating of oil -- a single steam gun working with 125 to 150 pounds of steam pressure can easily clean 1 square foot per min. Therefore 4 guns working under the same conditions could clean 4 Sq. Ft./min. or 240 Sq. Ft./Hr. These cleaning rates apply without any detergents or solvents being added.

Controlling Factors

1. *Bad Weather* - Pouring rain reduced the actual efficiency of the steam by cooling the work surface and by actually cooling the boiler tubes. (Heavy rain could penetrate the superheated exhaust and fall directly on the steam coils) During heavy downpours steam pressure became very eratic, while ordinarily during steady rain we kept up full operation.

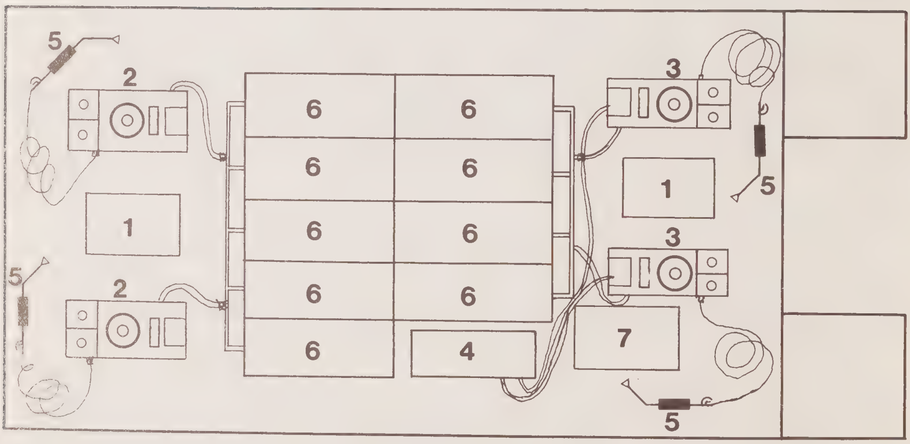
2. *Tide effects.* - The changing water levels from the tide had far more effect on our operation than was anticipated. It was neither low nor high for very long but was nearly always in the process of either exposing the surface to be cleaned or covering it up again. It was impossible to steam clean below the surface of the water, however the surface to be cleaned extended from above the high tide mark to the extreme low tide mark. This meant that any areas cleaned during a rising of falling tide had to be cleaned with a final sweep at low tide to finish parts that had been covered previously. Much time was spent in second sweep cleaning at different time/tide levels.

3. *Irregular work surfaces* - wharves to be cleaned were constructed from vertical creosoted timbers, horizontal timbers, bolted timbers, planks, rough tree poles, etc., some had solid walls, some were concrete capped, some had timber tops, some were open inside and some were filled with stone, some were lightly oiled and some heavily oiled, some were smooth, new wood and some were 20 year old rotten trees

FULLY EQUIPPED "CAT" LAYOUT

1. Fuel storage tanks for stove oil.
2. Gas engine driven steam generators.
3. Electrically driven steam generators.
4. Portable 2500 watt electric plant.
5. Steam guns with wide tips.
6. Fresh water storage tanks, 200 gal. each
7. Wheel house for 'Cat' used for storing gasoline, motor oil, spare parts, tools.

FULLY EQUIPPED "CAT" LAYOUT



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and some of the break-waters and retaining walls were constructed of large stones which had pools of oil between them.

4. *Occasional mechanical difficulties* - The gas- driven electrical generator was sometimes hard to start in the mornings due to continual dampness and the exposed nature of our craft. The burner tips on the steam had to be disassembled periodically for cleaning and adjusting. Water intake valves were damaged occasionally by small stones probably picked up from the variety of our water sources. The steam hoses were very durable but were 125 ft. long for each steam generator, and from time to time one or the other would be snagged or stretched causing a blow-out.

5. *Travelling time* - With her full load the 'Cat' had to be moved fairly carefully from jettie to jettie and real care had to be taken when long moves were necessary due to her low freeboard. Fog also hampered our small fleet on a number of occasions. However, travel was a must and about 20% of our time was spent in moving about.

CONTROL AND RECOVERY OF REMOVED OIL

As removed from the docks by steam cleaning the oil was highly fluid and thinned to just a little more than irridescence. In this condition it could not be recovered by the slick-lickers nor could it be scooped or netted. However, when it arrived on shore it could re-gather to heavy oil again. Therefore special control and recovery techniques had to be devised. This problem had been anticipated by the Project Oil Task Force and when our cleaning operation began we were instructed to use a practical and very efficient control and recovery procedure.

As the oil was removed from the docks it would fall to the water and fan out in thin slicks. A workman was positioned above the steamers on the dock and was assigned to spread peat moss on the floating oil. Peat moss has an affinity for oil and would soon absorb the oil. Other workmen were assigned the task of scooping up the oil-soaked peat moss in dip nets. It was then transported to dump sites in 45 gal. barrels.

As an extra precaution a boom net was positioned around the entire area where steaming operations were being conducted in order to contain any oil or peat moss which was not immediately recovered.

STEAM CLEANING FLEET VESSELS

1. The Catamaran -- as described.
2. An L.C.M. -- providing mobility, supplying fresh water and carrying supplies of peat moss.
3. An S.P. Barge -- used as a work platform from which to recover oily peat moss from the water.
4. The "Strait Queen" -- a Cape Island boat and her crew used to handle the boom and also as dip net handlers.